IBM

Reference Manual

3000 Accounting Machine

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Contents

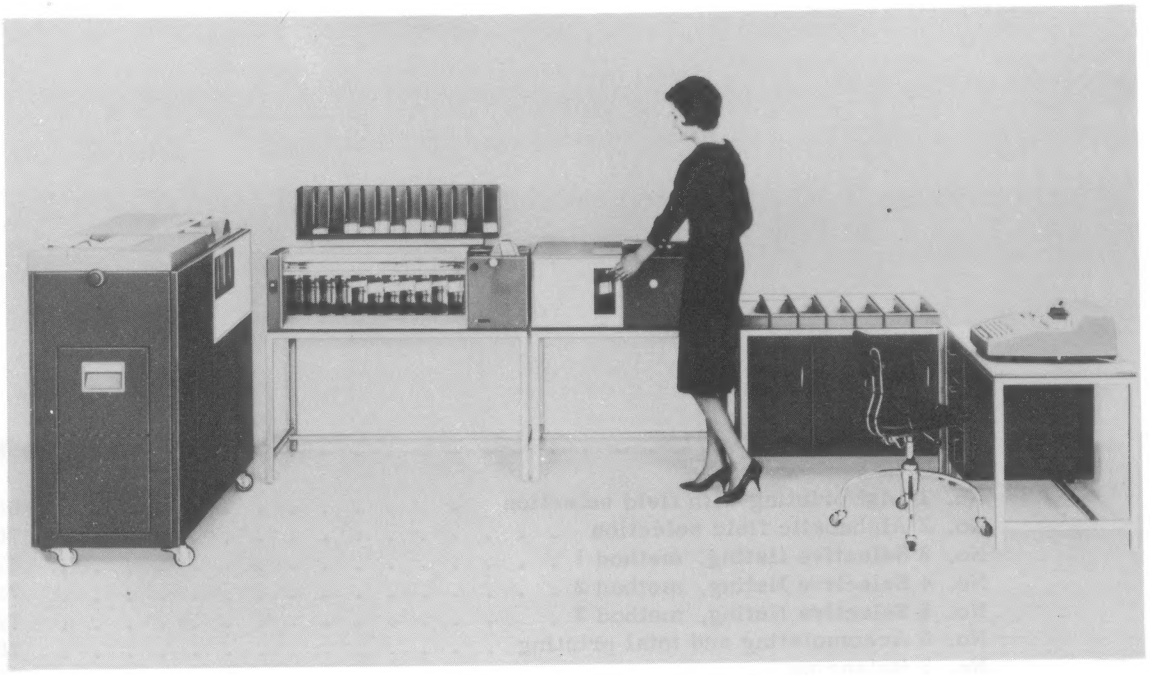


Fig. 1 IBM 3000 System

Foreword

This manual describes the method of operation of the IBM 3000 Accounting Machine and is intended as an aid in wiring control panels for the machine. Each chapter is self-contained and so it is not necessary to study them in the order in which they appear. An index is provided to simplify location of any particular point arising in the course of a problem.

In this first edition of the manual, technical reasons have made it possible to number the illustrations consecutively throughout the manual. Instead, the numbering is consecutive within each chapter.

Division, by control panel wiring, is not yet dealt with in this publication. It will be covered fully at a later date.

Introduction

The IBM 3000 Punched Card System consists of three basic machine types:

IBM 3020 Punch/Verifier
IBM 3080 Sorter
IBM 3000 Accounting Machine

and an optional additional macnine:

IBM 3050 Interpreter

The three basic machines correspond to the three basic steps in the mechanised production of reports and business documents:

1. Input data is expressed in the form of punched holes in small IBM cards by the IBM 3020 Punch/Verifier. This operation is followed by verification of the punched data by the same machine.

2. The punched and verified cards are automatically arranged in any desired alphabetic or numeric sequence, according to punched classification or control data in the card, by means of the IBM 3080 Sorter.

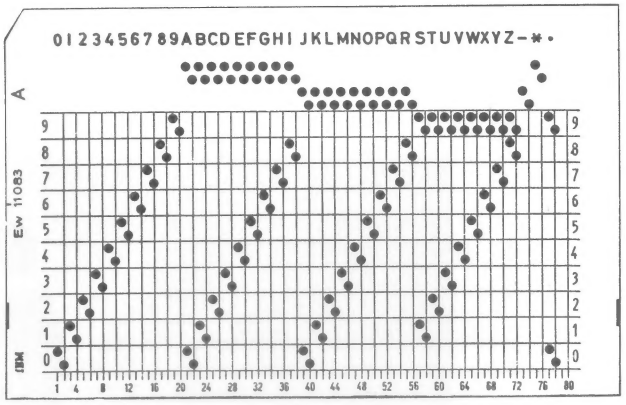
3. After the cards have been arranged in the required sequence, reports and summaries can be prepared automatically by the IBM 3000 Accounting Machine.

   This Machine reads cards and prints, in the required form, data read from them together with the results of calculations on such data. In addition to this, the machine is able to add, subtract, cross-total, multiply and divide data and can punch results and stored information into summary cards.

The IBM 3050 Interpreter is an additional machine which can print information punched in the card in two rows along the upper edge of the card (2 x 25 positions). In addition, a further 7 large digits can be printed, in either of the two rows, to aid card handling and reading.

This manual deals only with the IBM 3000 Accounting Machine. The other machines are described in the following publications:

3020 Punch/Verifier, Form 71 296
3080 Sorter, Form 71 297
3050 Interpreter, Form 71304



The 3000 System Punched Card

The punched card is divided into 80 vertical columns and 12 horizontal rows, giving 960 possible punching positions. The punching positions in each row are arranged so that odd-numbered columns are punched in the upper half and even-numbered columns in the lower half of the row. This staggered arrangement of punching, in conjunction with the use of small, round holes, makes it possible to permit the full 80 columns to be punched into this small size card.

Columns are numbered from 1 to 80, left to right. Each column can contain one alphanumerical character. The rows are numbered 0 1 2 . . . 9 11 12, from bottom to top.

Digits are represented by single punches in rows 0 to 9. Alphabetic characters are represented by two punches in a column: one digit punch in rows 0-8 and one zone punch in rows 9-12.

In addition to these digit and alphabetic punchings there are three symbol punchings: "12", "11" and "9/0", which are printed by the Accounting Machine as * - and / respectively.

Punched fields on the card correspond roughly with the individual print fields on a form printed by the accounting machine. Card fields are classified as alphabetic, numeric or alphanumeric (mixed alphabetic and numeric).

Original source data and hence the card fields can be divided into 3 classes according to the kind of information they contain:

1. Reference Information
   for example Account Number, Part Number, Item Number, Order Number, Salesman Number and so on.

   This information can be coded as desired and serves as a control for sorting into groups if, for example, a particular sequence is required for a report.

2. Indicative Information
   which can be regarded as a clarification of the reference data, for example Product Description for a particular Item Number.

   Reports, however, are usually more legible with purely numeric entries of code numbers.

   In this class of data also belongs, for example, addresses and statistical headings.

3. Quantitative Information
   which is the data that is to be processed; for example Amounts, Stock Quantities, Weights, Percentages.
   These figures are added, subtracted or multiplied, as required.

If cards of different classes, with different arrangements of data, are to be processed in the same application, then the reference data at least must be arranged in the same columns in all cards. In addition, the different classes of cards must be differentiated by identifying punches.

In numerical fields, only 0-9 punches are needed to represent digits. Therefore "11" (also known as "X") and "12" (also known as "R" or "Y") punches may be used for control purposes. Thus a negative amount is usually indicated by an "X" punch over the units position of the amount.

IBM 3000 Accounting Machine

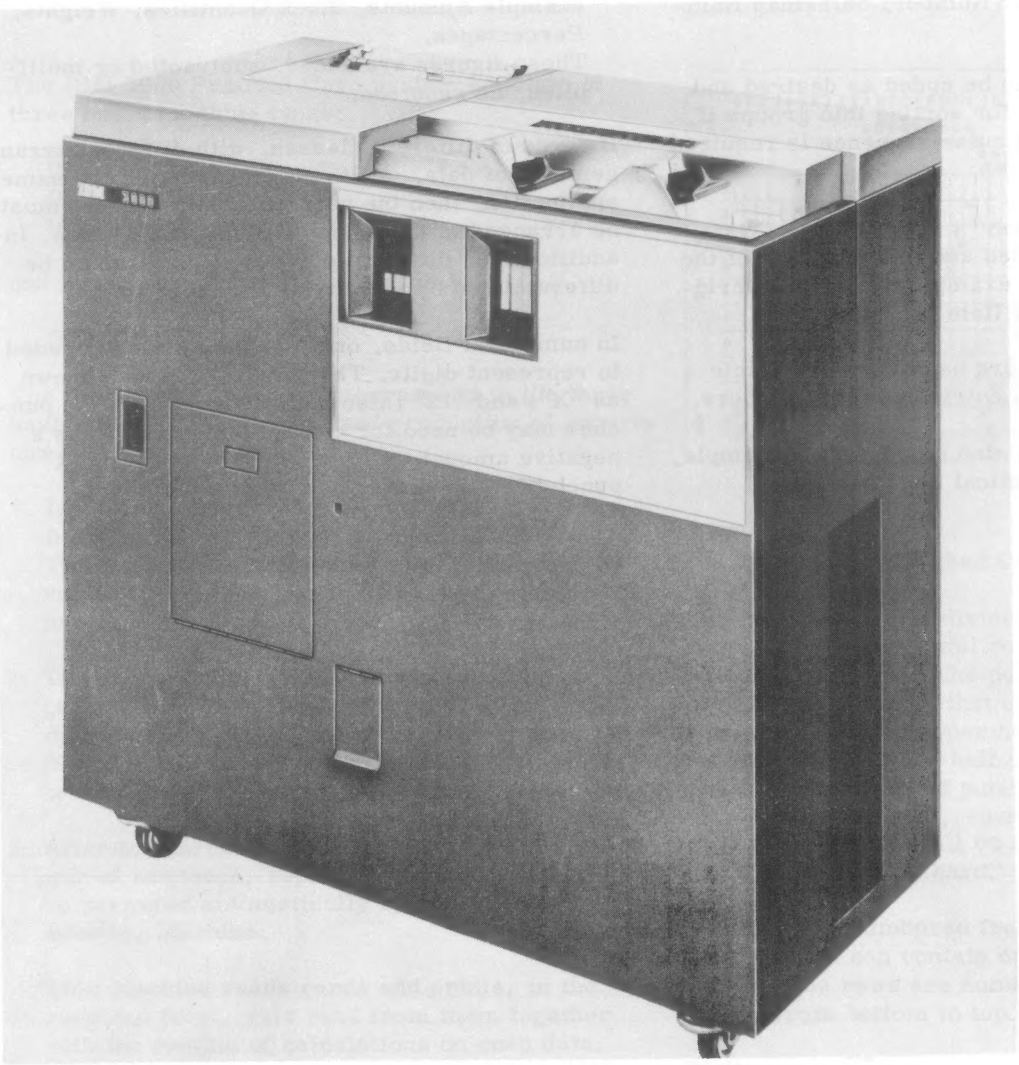


Fig. 2 IBM 3000 Accounting Machine

General

The IBM 3000 Accounting Machine has a far wider range of application than the normal type of accounting machine. By virtue of its unique design it can perform the following operations:

1. Print
2. Calculate
3. Reproduce
4. Punch
5. Gang-Punch
6. Summary Punch
7. (to a certain extent) Collate.

These main functions can be combined with one another, so that the machine is very versatile and can perform many jobs in one pass of the cards. The following examples illustrate only a few of the possibilities:

1. Factors read from cards could be used for calculations and the results listed and at the same time punched into the original cards.

2. Summarised totals could be punched into the last card of a group or into a separate summary card, and these cards separated from the other cards.

3. In one run, it would be possible to separate out the master cards, containing a constant

multiplier for the group, to multiply factors from each detail card and to list the products whilst simultaneously punching them into the original cards. At the same time, summary cards could be punched for each group.

The following block diagram shows the various machine functions:

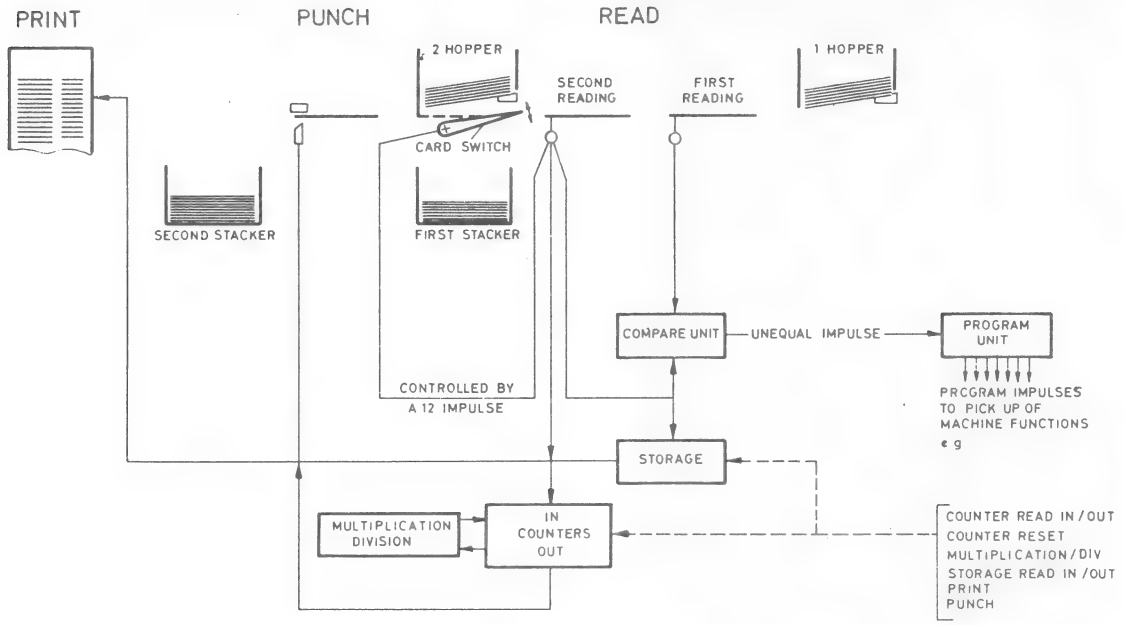


Fig. 3 Data Flow Diagram

External Features

Main Switch

The main switch is located on the front of the machine, to the left. When this is switched on the IDLING lamp lights and the machine is immediately ready to operate. The main switch should only be turned off when the machine is idling, otherwise data in storage and in counters may be lost.

Hopper

Two card hoppers are located at the upper right front of the machine, each with a capacity of approximately 550 cards. Cards are inserted face down, 12 edge leading. A card weight should be placed on top of the cards, to ensure correct feeding of the last card.

In the first hopper are placed punched cards which are to be processed by the accounting machine. Cards in this hopper can be stacked in either hopper as desired.

In the second hopper are usually place unpunched cards which are to be punched as results cards or summary cards in the punch station.

Reading

Cards from the first hopper pass in turn through two reading stations. Here punches in the 80 columns of the card are read. The corresponding impulses are made available at the First or Second Reading hubs on the control panel.

Card Selection

A card from the first hopper is able, by means of a card switch controlled from the control panel, to stack in either the first or the second stacker. This feature greatly adds to the versatility and flexibility of the machine.

Punch Station

Cards from both the first and the second hoppers can be punched at an 80 column punch station. Information to be punched can be obtained from another card (Reproducing) or from counters or storage (Punching).

Stackers

The machine has two card stackers, each with a

capacity of approximately 550 cards Each pocket is fitted with stop contacts to stop the machine when the stacker pocket is full.

Fig. 4 Control Panel

Control Panel

Machine operations are controlled by wires in a removable control panel in conjunction with the settings of control switches. The control panel is a two-part plate of insulating material in which are bored holes known as hubs. Behind the control panel, in the accounting machine, are a set of fixed contact springs, one to each hub. Wires, inserted into the control panel, complete electrical connections between these springs so that an electrical impulse emitted from one of them can be taken through the other to a different part of the machine. This gives the machine great flexibility, enabling it to meet the varied requirements of practice. With the aid of the control panel, the machine is instructed to perform any required operations. A very great variety of reports can thus be prepared by the machine. By inserting a different control panel the machine can be changed over to a new application in a few moments. Likewise, the wiring on any control panel can be easily modified.

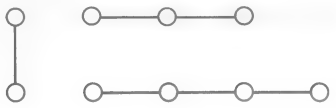
To aid reference to a particular control panel hub location, the 64 horizontal rows of hubs are lettered A to BL and 40 vertical columns are numbered 1 to 40. Each hub can therefore be referred to by its co-ordinates: for example the All Cycles hubs have the locations P/21-24.

Hubs are of three different types:

1. Exit hubs (hubs which emit impulses)
2. Entry hubs (hubs which accept impulses)
3. Filter hubs (hubs which filter or select impulses).

Whether a hub can emit, accept or select impulses, at a particular time depends on various conditions (card reading, wiring, type of machine cycle, etc). Some hubs can, at different times, both emit and accept impulses; other exit hubs must never receive "back-circuits". Details are given in the Control Panel Summary and Timing Chart.
Hubs having associated functions are grouped together on the control panel and such groups are identified by heavy outlines. Control functions are brought to the upper half of the control panel whilst the lower half is mainly concerned with data flow.

When two or more hubs are connected together by a line, they are known as common hubs. They are internally joined together and avoid the need for split wiring, which tends to obscure the wiring.



Common hubs

Some hubs are joined by arrows:

Pluggable Switches

In this case the hubs form a pluggable switch, which can be jackplugged to make the particular function operative. The arrow indicates that, in general, the entry hub of the switch (head of arrow) should only be connected with the exit hub of the same switch (tail of arrow). Exceptions to this rule are explicitly described.

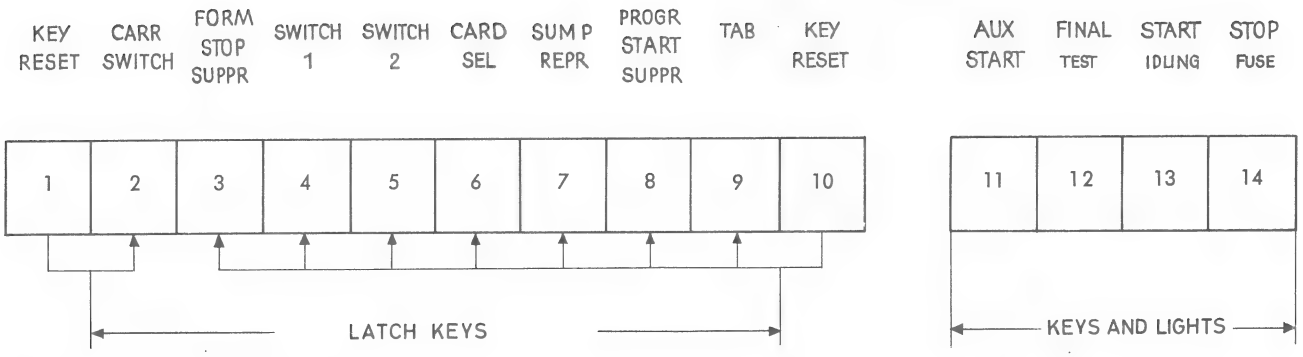


Fig. 5 Keys and Lamps

On the top surface of the machine are located 14 operating keys. In the description below, the keys are given numbers. These are for explanatory purposes only; on the machine they are not numbered.

Keys 2 to 9 are latch keys; that is, once depressed they remain in this position until one of the reset keys, numbers 1 and 10, is depressed. Key 1 resets key 2; Keys 3 to 9 are reset by pressing key 10.

1. KEY RESET

Pressing this key restores Key 2 (Carriage Switch) to its normal Position.

2. CARRIAGE SWITCH

A form can be restored to its home position by depressing first the Carriage Switch followed by the Final Key (No. 12). A carriage skip will occur, stopped by a hole in channel 7 of the tape. No control panel wiring is needed for this. Now the first printing line of the form can be positioned accurately by means of the two platen knobs. Following this, the Reset key (No. 1) must be pressed to release the Carriage key, because otherwise the start key (No. 13) will not be operative.
The carriage key must not be depressed whilst the machine is in operation (say, in order to stop the machine), because damage to the machine can result.

3. FORM STOP SUPPRESS

Continuous stationery in the carriage is normally detected by a forms contact which causes the machine to stop when the end of the paper is reached. If the machine has been stopped for this reason and printing on the last form needs to be completed, or else a single form has to be run off for testing purposes, this key must be depressed.

4 SWITCH 1 AND 2
&
5 Two 4-position selectors are provided on the control panel which are Normal unless the corresponding Switch key is depressed, in which case the selectors are Transferred. By use of these switches, certain functions on a control panel can be modified. In this way, it is possible to wire a number of different applications on the same control panel, provided that the differences are not too great.

6. CARD SELECT

This key must be depressed for all applications in which any of the cards from the first hopper must pass through the punch station and be stacked in the second stacker.

7. SUMMARY PUNCH AND REPRODUCE

This key must be depressed for all applications in which cards are to be fed from the second (punch) hopper. If either of the hoppers is empty or the last card is fed, the machine stops.

8. PROGRAM START SUPPRESS

If this key is depressed, an impulse to one of the Program Start hubs will not cause a program to take place. This may be used during control panel testing.

9. TABULATE
If this key is depressed, cards are fed without printing. In this case, if printing is required during particular card cycles, the Print PU hubs (U-V/13) must be impulsed. If, in addition, the Control FC switch (C-D/21) is jack-plugged, printing takes place in the first card cycle after any program.

10. KEY RESET

Pressing this key releases and resets any of keys 2 to 9 which were depressed.

Keys 11 to 14 are not latch keys and so automatically return to their OFF position after being depressed. These keys are also fitted with signal lamps to indicate certain conditions in machine operation.

11. AUXILIARY START KEY AND LAMP

When a feed interlock occurs (when a card in the first hopper fails to feed), this lamp lights and the machine stops at the end of that particular card cycle. Nothing is printed in this cycle and the Card Cycles, First Card, and First and Second Reading hubs to not emit. The Start key is then inoperative until the feed interlock has been cleared, as follows:

1. All cards in the first (and second) hopper are removed.
2. All cards in the first (and second) stacker are removed.
3. The Auxiliary Start key is then held down until all the cards in the machine have been run out.
4. These cards (from the first stacker) are then placed in front of the cards from the first hopper and the combined pack of cards is replaced in the hopper.
5. The Auxiliary Start Key is then held down through the run in cycles until the machine runs continuously whereupon the Auxiliary Start lamp extinguishes.

12. FINAL KEY

This key has 3 functions:

a) When the card bed is completely empty, depressing the Final Key initiates a print cycle. The four Final hubs on the control panel (D/21-25) emit a Cycle impulse, which is usually used to print a final total or to reset counters.
b) When a reset error occurs, that is when a Counter Reset hub is impulsed and the counter (due for example, to faulty control panel wiring) does not reset correctly to 0, the machine stops with the Test lamp on at the end of the next cycle. The First and Second Reading hubs do not emit during this last cycle. The Test lamp and the "Reset Error" condition will be reset by depressing the Final key. Without this, the machine cannot be made to run continuously. In addition, the All Cycles Hold hub emits a continuous impulse as long as the Test lamp is alight. When a reset error has occured, it is advisable to re-process the last portion of the job.
c) The Final key is also used in restoring forms to their home position (See Key 2).

Test Lamp

This lamp has two functions:

a) In the event of a reset error, this lamp burns continuously until extinguished by depressing the Final key.
b) This lamp flashes if, during a counter read-in cycle, controlled by an impulse to Counter Read In Plus or Minus, any position of the counter does not receive an impulse. The machine can be wired either to stop or to run on. In addition, an A impulse is available from the BC hub (AI-AJ/16) which can be used to print a symbol (/) on the same line.

13. START KEY

If the start conditions are fulfilled (see the "Run Control and Card Transport" Chapter) depressing this key causes the machine to take at least one machine cycle. For the machine to run continuously, further conditions, the so-called run conditions, must be satisfied.

Idling Lamp

This lamp lights when the machine has its power switched on but is not operating.

14. STOP KEY

When this key is depressed, the machine stops at the end of that cycle. A program or a multiplication will be completed before the machine stops.

Fuse Lamp

If a fuse burns out, the machine stops and this lamp comes on. Operations can be resumed as soon as the fuse has been replaced.

Note:

The Run Control and Card Transport Chapter contains further information on operating keys nos. 6, 7, 8, 11, 13 and 14.

Print Unit

The print unit of the accounting machine is continuous and consists of 70 print segments, of which the first 5 and the last 40 are numeric and positions 6 to 30 are alphanumeric.

A numerical print segment contains type for

10 digits	0 - 9
3 signs	* - / (Asterisk, Minus, Oblique)

Each print segment contains all the necessary characters, therefore all positions wired for printing can print simultaneously in a print cycle so that printing takes place line by line.

The print unit is 7 inches (18,8 cm) wide, thus there are 10 characters to the inch (2,54 cm). The line spacing is 1/6th inch.

Print segments can print information punched in cards, held in storages or calculated in counters. In addition, constant alphabetic or numeric information can be printed, under control of control panel wiring, from the emitter. Impulses from machine units or read from cards set up the corresponding letter or digit in the print segment. A hammer-trip, common to all print segments, then prints all the information to be printed on that line simultaneously.

Normally the machine makes every card cycle a print cycle. If this is not required, the Tabulate key can be depressed so that printing is entirely suppressed or occurs only for the first card of a group or at any other desired time depending on control panel wiring.

Zero Printing

Raising the print unit cover provides access to the print unit and to the hammpersplit levers in front of it. Every print segment has its hammersplit lever to control zero printing.

For a print position to be able to print a zero, two conditions must be satisfied:

1. That particular print position must receive a zero impulse.

2. A print position to the left must print a character and must not have its hammersplit lever raised.

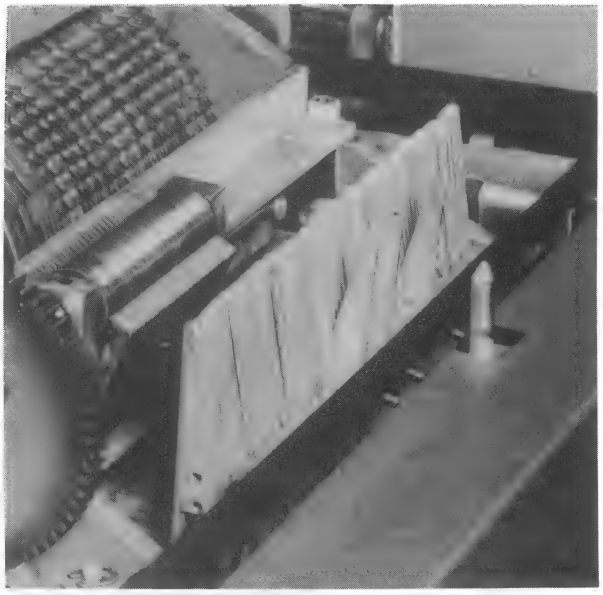


Fig. 6 Hammersplit Levers

From this it follows that a zero cannot print in the first print position.

By raising hammersplit levers, using the tubular wrench supplied, the print unit can be divided into different print fields in which zeros will only be printed if they are to the right of significant digits.

An alphabetic character, a digit 1-9 or a symbol will thus allow zeros to print in positions to the right of them only as far as, and including, the next "split" position, provided of course that these positions receive zero impulses.

Example:

Hammersplits:

none raised:	170	00231	0012100
raised on junior positions:	170	231	12100

raised hammersplits

Note: Not more than 10 consecutive zeros can be printed on one line.

Form Feeding

The next two illustrations show the path taken by forms through the carriage.

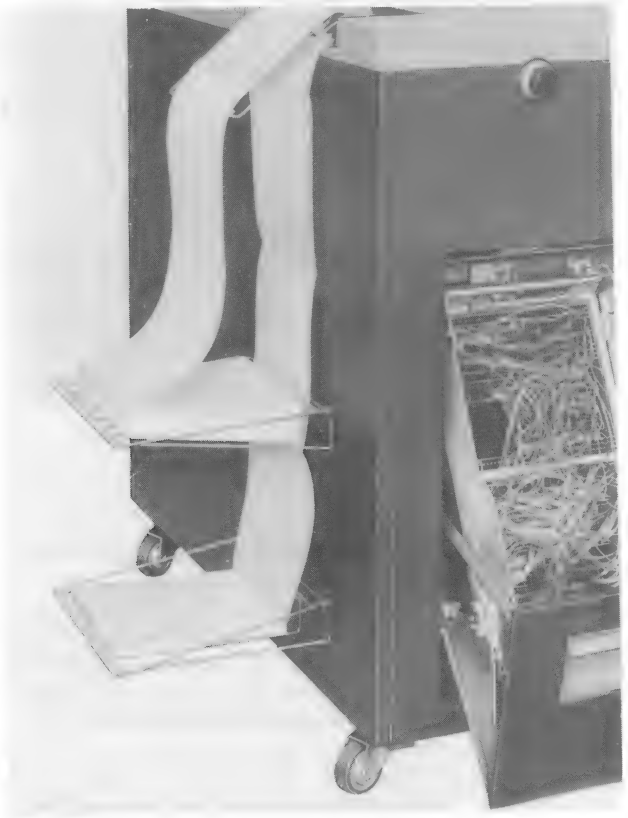


Fig. 7 Forms Trays

At the rear of the machine holes are pierced in the casing at six different levels, into which the two forms trays can be fitted. Into the lower tray are placed the forms about to be fed into the machine; after passing through the machine the forms fall by their own weight into the upper tray. Horizontally folded ("zig-zag") continuous stationery is recommended, either preprinted or unprinted. This should be obtained from the printer in packs of between 250 and 1000 sheets, depending on the paper thickness and the number of parts in the set. (see the "Continuous Forms" Chapter for further details). However, it is also possible to use reels of unperforated paper, having no marginal holes.

Forms movement through the carriage with accurate maintainence of line and column positioning is achieved by pin-wheel feeding. If this method of feeding is to be used, the pressure rolls must be withdrawn from the platen; that is, the lever at the right-hand end of the platen must be moved forwards.

This lever has to be moved to the rear only if paper is to be gripped by the pressure rolls, that is if roll paper is to be fed without using marginal punched holes or if, when inserting forms, the first sheet has to be transported around the platen.

In the next illustration the carriage cover is opened to show form feeding, pin-wheel feed, platen knob, adjustment, print unit, ribbon mechanism, hammer splits and carriage control tape (see also illustration in the "Tape Controlled Carriage" Chapter).

Fig. 8 Form Feeding

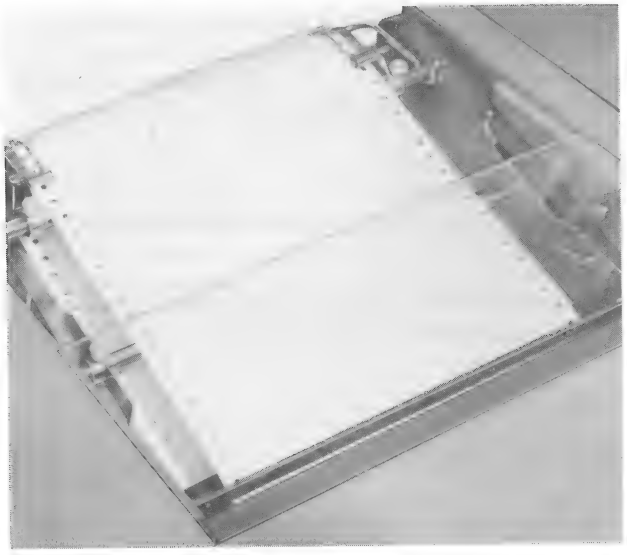
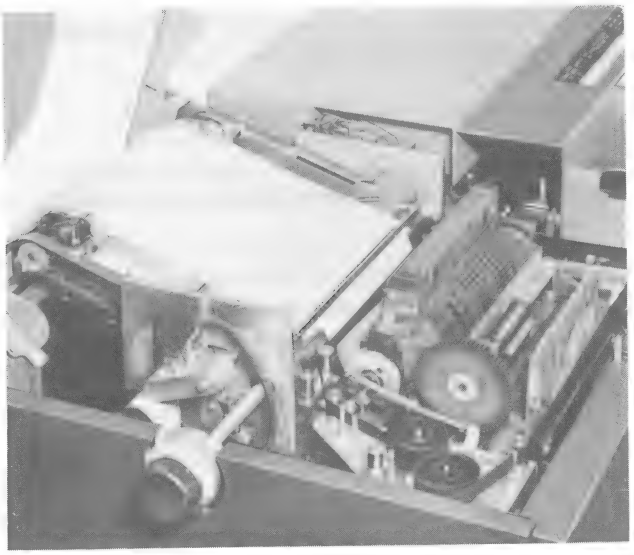


Fig. 9 Print Unit, Cover Raised



The print unit of the accounting machine is fitted with pin wheels which insure trouble-free feeding of marginally punched continuous stationery and guarantee accurate line spacing. Since the results of accounting machine operations depend to a certain extent on the characteristics of the stationery used, the technical specifications for the printing of forms are summarized in this chapter. These specifications, if followed, give maximum operating efficiency. They are not intended to be restrictive but rather are intended to permit customers to purchase their continuous forms from the manufacturer of their choice.

Characteristics of the paper

The paper used for continuous forms must be of sufficient weight and strength to prevent the holes from tearing out during feeding or ejecting of the form. This is particularly important when single part forms are being used.

The paper must not be so stiff as to cause improper "wrap around" or excessive bulging particularly at the outfold. Paper must be as free from paper dust or lint as possible.

Weight of paper

The weight of paper for a multiple card set is dependent upon the number of legible copies required. Best results on multiple copy forms require a light weight paper of 7 lb (28,5 gr. per m^2). Only the top copy and the last copy should be thicker.

Multiple part sets

Form length and carbon paper length should be equal. The maximum tolerances for variation in form and carbon dimensions, due to processing and various atmospheric conditions, are:

\+ 0.012" (0,3 mm)) per 11" (DIN A 4)
\- 0) length of form.

Multiple copy forms consisting of more than four parts and forms with the first part made of paper of more than 12 1/2 lb weight (50 g per m^2) should be tested under operating conditions to determine the suitability of feeding and legibility.

One-time carbon paper or carbon-backed paper can be used. The carbon paper or coating should produce the required number of legible copies without excessive smudging. This can best be determined by making test runs of sample sets of forms containing different qualities of carbon papers.

Marginal holes

Continuous forms should have holes in both right and left hand margins. The pins of the paper feed mechanism engage in these holes to maintain the form in the correct position.

The pins of the paper feed mechanism are 1/8" (3,17 mm) in diameter. To allow the pins to engage in the paper and to withdraw freely, without tearing the paper, the diameter of the feed holes must be larger than that of the pins. The optimum is 5/32" (3,97 mm). To correspond with the interval between successive pins, the distance between adjacent holes must be 1/2" (12,7 mm) between centres.

Width of forms

Marginally punched forms can be up to 10 3/4" (273 mm) wide, including margins. Rolls of paper without feed margins can be up to 11 3/4" (300 mm) in width.

Fastening of multiple copy forms

The width, length and number of copies of the form and the type of aligning device determine the fastening requirements for satisfactory feeding of the form set.

Marginally punched continuous form sets of three or fewer forms need not be fastened together if all forms are of the same width. If the form set is of four parts or more, or if the forms are different widths, the necessity for and the method of fastening the form should be determined by the width of the parts, the depth of the form and weight of the paper.

The recommended maximum distances between fastenings are:

FORM DEPTH	MAXIMUM INTERVAL
1- 5" (24-127 mm)	5" (127 mm)
5-14" (127-280 mm)	11" (280 mm)
11-14" (280-356 mm)	7" (178 mm)
14-17" (356-432 mm)	8 1/2" (216 mm)

For forms more than 17" (432 mm) deep, the maximum distance between fastenings should be determined by actual test. Multiple part forms

should be held together in some manner, such as by stitchning, gluing or stapling. The method of fastening should not interfere with feeding or printing of any of the forms.

Lenght of forms

by stiching, gluing or stapling. The method of
The individual forms can be of up to 22" (555,8 mm) length between perforations. It is recommended, however, that the form length be confined to standard sizes.

Perforations

The perforations between forms should be sufficiently deep to permit easy separation but not so deep as to tear in ordinary handling or feeding through the machine. The perforated lines at the end of the form should always be located between the marginal holes and at 90° to a vertical centre line through the marginal holes. Cut and uncut portions should be uniformly accurate in length and spacing to insure proper and efficient tearing.

Vertical perforations at the margin for removal of the marginally punched strip can vary depending upon requirements. The distance from the edge of the form to the marginal perforations is usually 1/2".

Registration of forms

The assembly of multiple copy forms should insure that the punching and printing of all copies of the form are in absolute registration with the print format of the Accounting Machine and within the tolerances given here.

Vertical lines

Vertical centre lines of print segments are spaced 1/10" (2.54 mm) apart, which gives a printing width of 7" (177,8 mm) for 70 print-positions. The spacing of 10 characters per inch permits a plus or minus tolerance of only .005" (0,13 mm) from the true print segment location, which means a maximum overall tolerance of 0.01" (0,27 mm).

Vertical rules printed on a form should be spaced in multiples of 1/10" (2,54 mm) from the left margin. For technical reasons it is virtually impossible to guarantee that the accumulated tolerance of printing plate shrinkage, paper shrinkage and marginal hole perforations will not exceed these tolerances. This precludes the possibility of maintaining satisfactory registration if vertical rules are spaced to occur between adjacent print positions. Therefore, when designing forms layout for these machines, the practice of drawing vertical lines between the print positions to separate columns in a field should not be followed.

Where vertical lines are required, the rule should come in the middle of a type position, which prevents use of this position for printing.

Vertical printed lines should be parallel to a vertical centre line passing through the marginal holes.

Horizontal lines

Horizontal printed lines on the form should be at a 90° angle to the vertical centre line passing through the paper feed pin holes. The spacing of these horizontal lines should conform with that of the print unit: 6,3 or 2 lines per inch.

Ribbon

The quality of printing by an accounting machine is dependent to a large extent on the quality of the ribbon. The type of fabric plays an important part in the various applications. Only the correct ribbon (IBM part No. 154 438 - silk, black, dry-inked) should be used for the IBM 3000 Accounting Machine.

A selector is an electrically operated switch having a number of switch contacts, each of which has three hubs on the control panel, labelled:

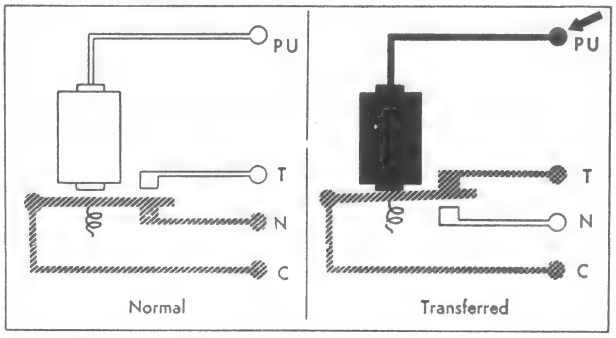
T Transferred
N Normal
C Common

When the selector is Normal, that is, when there is no current passing through its pick-up coils, the Common hub of each contact is internally connected with the Normal hub. When the selector is Transferred, its common hubs are internally connected with the corresponding Transferred hubs.

The following terms are used to describe selector operation:

A selector is Normal,
then is picked up,
so that it transfers.
When Transferred,
it can be held (stays Transferred)
or dropped out (reverts to Normal)

By using a selector, an impulse can be directed to one or other of two destinations, or impulses from one or other of two different sources be directed to a given destination, to control machine functions or to alter the flow of data.

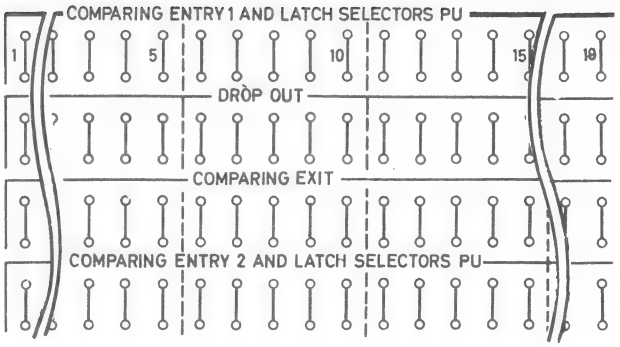


Schematic diagram of selector operation

The IBM 3000 Accounting Machine possesses two kinds of selector:

Latch Selectors and Co-Selectors.

COMPARING AND LATCH SELECTORS
C-J/1 - 8
C-J/26 - 40
O-R/1 - 9
AG-AJ/1 - 15



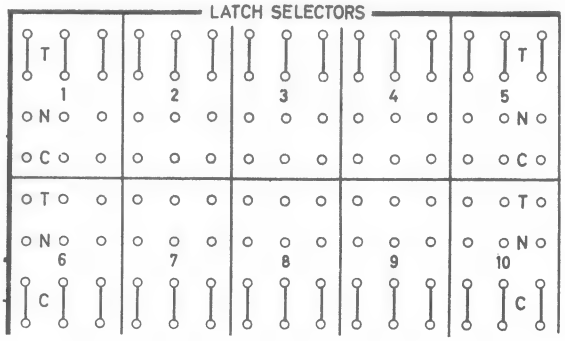
The machine is equipped with 18 three-position latch selectors.

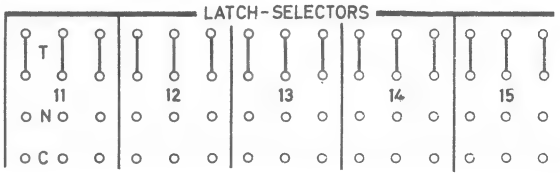
Three double hubs are provided for controlling each of these selectors:

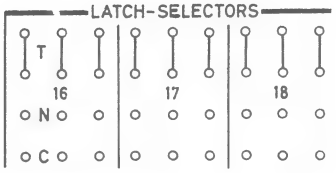
2 Pick Up hubs
1 Drop Out Hub

Only short impulses (not, for example, Cycle impulses) may be wired to these hubs.

A selector transfers as soon as one or other of its Pick Up hubs receive an impulse and remains transferred (latched) until its Drop Out hub is impulsed.







If both Pick Up hubs receive impulses simultaneously, the selector does not change its status, that is, if Normal it does not transfer, if Transferred it remains so.

Because of this property, latch selectors can be used as comparing units, for group control.

Pick Up and Drop Out must not be impulsed simultaneously because then operation of the selector will be unreliable.

The Comparing Exit hub of a latch selector emits a B impulse in every card cycle in which the selector is transferred. This may be used to control a wide range of machine functions (see Timing Chart).

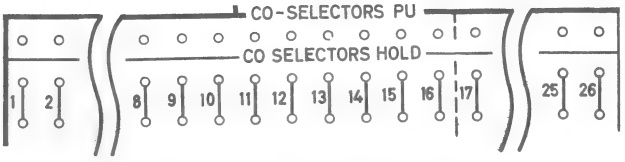
The switch contacts (points) of the latch selectors are brought out to three different locations on the control panel. To simplify wiring and to avoid split wires and split-wire connectors, latch selectors 6 to 10 and 11 to 18 have double Transferred hubs and latch selectors. 6 to 10 have double Common hubs.

CO-SELECTORS

AD-AF/15-40
AG-AJ/17-40
AO-AQ/1-40
BA-BC/1-40

The machine has 26 four-position co-selectors which operate similarly to latch selectors and which may be used to control machine functions or data flow. Each co-selector has two Pick Up hubs:

1 Pick Up hub
1 Hold hub.



These two hubs are identical in function and can be impulsed with any impulse, long or short. The Hold hubs are doubled, to facilitate coupling of co-selectors.

In contrast to latch selectors, co-selectors only remain transferred for as long as one or other of their pick up hubs receives an impulse. Thus extra control panel wiring is needed to hold co-selectors transferred. For this purpose a longer impulse, such as an FCC, Program or Cycle Hold impulse or a Cycle impulse, may be wired via the Common and Transferred hubs of that same selector into its Hold hub. The selector then holds, after being picked up by a short impulse, until the end of the Hold impulse wired through its Transferred point.

If further co-selectors are to be coupled to this one, the Hold hubs of all these selectors should be wired together, so that they are all held by the Hold impulse for the first.

The points of co-selectors are brought out to three different locations on the control panel:

Wiring and employment of selectors are amply described in the various Wiring Examples.

The IBM 3000 Accounting Machine is equipped with 9 four-position and 3 seven-position counters (57 counter positions). Each counter can add or subtract amounts received from cards, from other counters, from storage or from the emitter. The accumulated totals can be read out for printing, for punching or for transfer to storage or to other counters. Counters can be coupled as required, irrespective of whether they are adjacent on the control panel or not, to form counter groups of correspondingly greater capacities. With the aid of counters, the machine can also perform multiplication and division.

Multiplication and Division

The multiplication device can develop a product of a maximum of 15 digits, from a 7 position multiplier and an 8 position multiplicand. Multiplication can be started after any card cycle or any program cycle, and the multiplication cycles then take place at 3 times the speed of machine cycles. During a multiplication all other functions are suspended.

The same device that is used for multiplication is also used to perform divisions. The maximum size of the factors are a 14 digit dividend, and a 7 position divisor.

The time taken to carry out a multiplication depends on the number of digits in the multiplier, and their value:

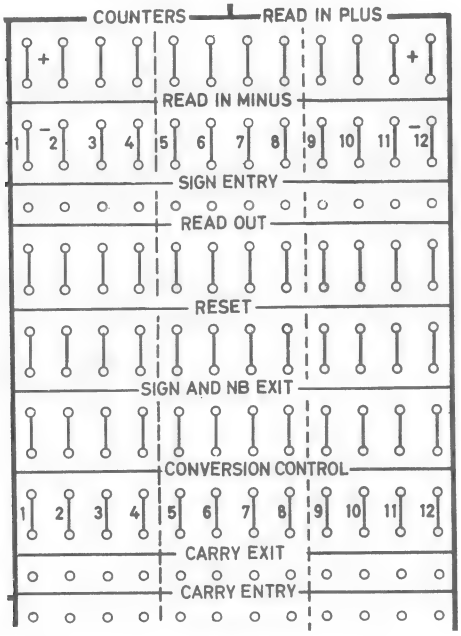
Value of each digit in the multiplier		Number of multiplication cycles
1	=	1 multiplication cycle
2	=	2 (1/3 machine cycle)
3	=	3
4	=	4
5	=	5
6	=	5
7	=	4
8	=	3
9	=	2
0	=	0

The time taken to carry out a division depends on the number of digits in the quotient and the total of these digits.

The following table shows the approximate number of cards per hour for multiplication and division respectively.

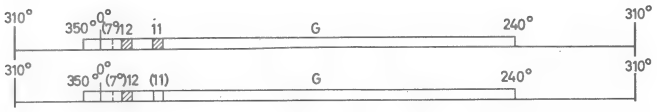
	Speed of Multiplication			Speed of Division
Number of digits in multiplier, quotient respectively	Maximum (one mult. -cycle per multiplier position) cph	Minimum (5 mult. -cycles per multiplier position) cph	Average (3 mult. -cycles per multiplier position) cph	Average cph
1	1 800	1 350	1 350	1 080
2	1 800	900	1 080	770
3	1 350	675	900	540
4	1 350	600	770	450
5	1 350	490	675	385
6	1 080	415	600	315
7	1 080	385	540	285

Counter functions are controlled by the following control panel hubs:



The functions:

READ IN PLUS
READ IN MINUS
READ OUT
RESET

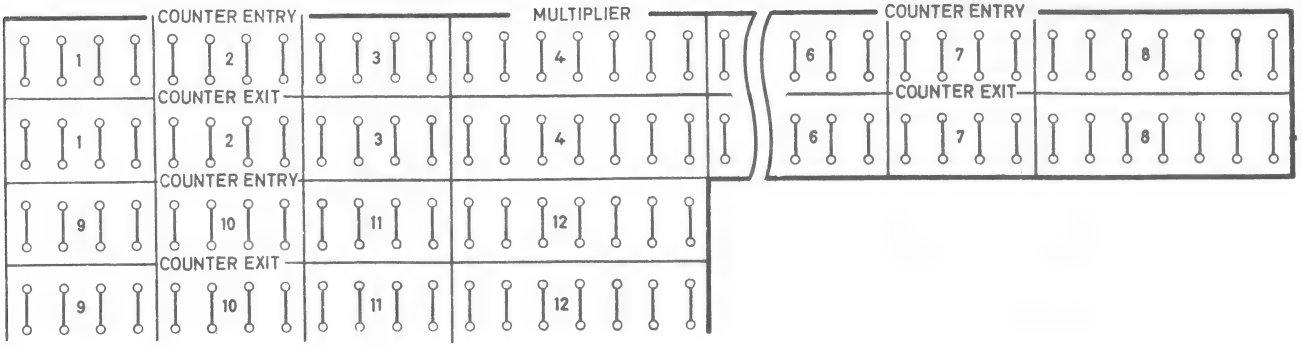


of counters can be controlled by 12, 11 or Cycle impulses. If, however, the counter contains a negative amount and the Negative Balance impulse is needed to control conversion or to print a minus sign Counter Read Out should not be controlled by an 11 impulse. Impulses which continue later than 240°, for example the Cycle Hold impulse, must never be used to control counter functions.

Each counter position is provided with a double Counter Entry hub and a double Counter Exit hub.

These hubs only accept (or emit) if the appropriate counter is controlled to read in (or read out).

Counters can be assigned and coupled as required, with only the slight restriction that, for a multiplication, the multiplier must be held, as a positive number, in counter 4. After the multiplication, this counter is automatically reset to zero.

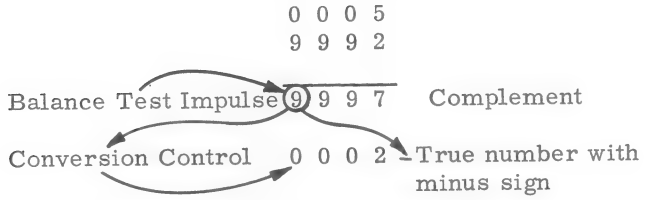


If subtraction has to be performed in coupled counters, the Cary Exit hub of the senior counter must be wired to the Carry Entry of the junior counter, in addition to the normal wiring for counter coupling.

The following example

$$\begin{array}{r} 5 \\ -\ 7 \\ \hline 2 \end{array}$$

gives a negative result. The machine calculates:



The machine recognises that a counter contains a negative amount by the 9 in the senior position. When this counter is instructed to read out, its Sign and NB Exit hub emits an 11 impulse, which is usually wired to Conversion Control and to a Print Entry to print a minus sign or to a Punch Entry to punch an X punch for negative balance indication.

If a job requires counters to subtract as well as add, care should be taken to ensure that the capacities of the counters are always at least one position larger than the largest balances which can possibly be developed in them, because the senior position of each counter is needed to identify negative balances. If this position stands at 9, the balance is negative, if at 0 the balance is positive.

Amounts held in counters in complementary form are usually converted to true form for transferring to other counters, as well as for printing.

Further details of counter functioning are given in sections 47 to 63 of the Control Panel Summary chapter and also in the Wiring Examples.

METHOD OF MULTIPLICATION

Multiplication is a short-cut addition:

$$4 \times 4 = 3+3+3+3 = 12$$

that is, the multiplier 3 shows how many times the multiplicand 4 must be added to produce the product 12.

Multiplication of multi-digit numbers can rarely be done in one step. This can be done, but only to a limited accuracy, with a slide-rule. With this, for example, the result of the multiplication 1234 x 273 = 336882 can be obtained correct to, at the most, three figures: 336...

Manual multiplication is reduced to step-by-step addition, since a partial product is calculated for each digit of the multiplier and, finally, these partial products are added:

$$\begin{array}{r} 1234 \times 273 \\ \hline 3702 \\ 8638 \\ 2468 \\ \hline 336882 \end{array}$$

This multiplication was carried out by the following formula:

$$1234 \times 273 = 1234 \times 3 + 1234 \times 70 + 1234 \times 200$$

or

$$1234 \times 273 = 1234 \times (3+70+200)$$

A simple desk calculator or adding machine usually multiplies by repeated addition:

$$\begin{array}{rr} & 1234 \\ \times & 273 \\ \hline & 1234 \\ & 1234 \\ & 1234 \\ & 1234 \\ & 1234 \\ & 1234 \\ & 1234 \\ & 1234 \\ & 1234 \\ & 1234 \\ & 1234 \\ & 1234 \\ \hline & 336882 \end{array}$$

The number of rotations of the hand-lever can be reduced if, for multiplier digits of 6, 7, 8 and 9, the multiplicand is first added once, ten times larger, followed by 4, 3, 2 or 1 subtractions of the actual multiplicand. For the example already quoted, the formula may be modified:

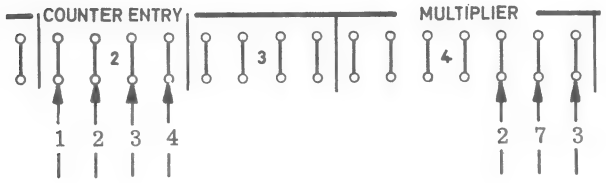
$$1234 \times 273 = 1234 \times (3 + \underbrace{100 - 30}_{70} + 200)$$

or

$$\begin{array}{rr} & 1234 \\ \times & 273 \\ \hline + & 1234 \\ + & 1234 \\ + & 1234 \\ - & 1234 \\ - & 1234 \\ - & 1234 \\ + & 1234 \\ + & 1234 \\ \hline & 336882 \end{array}$$

This "short-cut" method is used by the IBM 3000 (see also Wiring Examples 10-14).

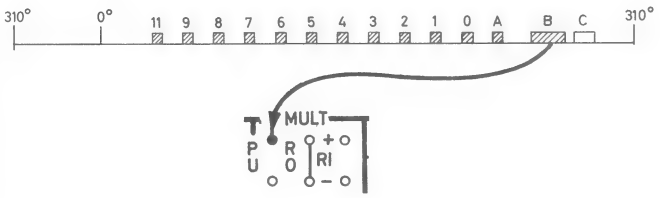
Prior to a multiplication, the two factors must be positioned in the appropriate counters:



The multiplicand can be placed in any desired counter, with the exception of counter 4. Here, counter 2 has been chosen.

The multiplier must be placed in counter 4 because this counter has additional circuitry to enable it to control the progress of a multiplication. It is recommended that the factor with the fewest digits be chosen as the multiplier, because then the multiplication will then be completed more quickly.

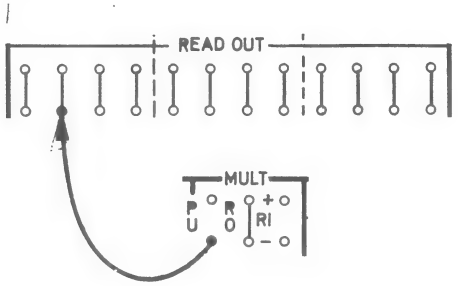
Multiplication can be initiated by any short impulse 11-C to either of the two Mult PU hubs.



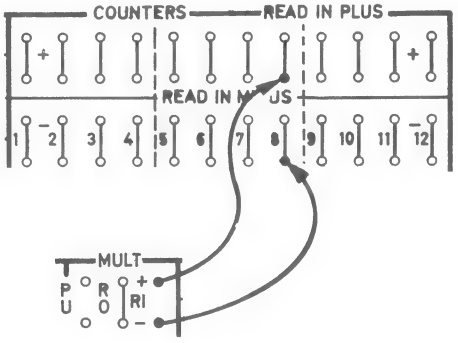
The two Mult switches must be jackplugged to allow multiplication to take place

During the multiplication, the machine takes Multiplication Cycles, which are three times the speed of normal machine cycles. The majority of other functions not concerned with multiplication are suppressed. The Timing Chart shows details of these. It should be noted that some functions also occur during multiplication, but at the normal cyclic rate - for example the emitter.

The Mult RO controls the read out of the multiplicand counter in every multiplication cycle. In this example, counter 2 emits the multiplicand in each multiplication cycle:

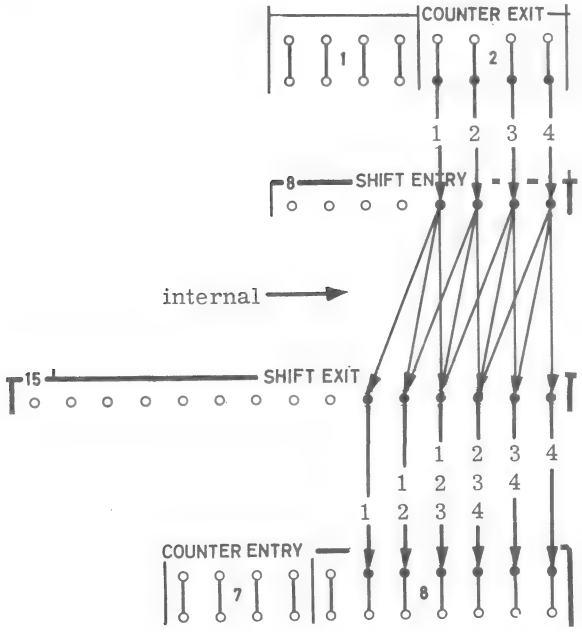


This multiplicand has to be added to or subtracted from the product counter (counter 8, here) according to the particular multiplier digit. This function is controlled automatically by the Mult RI ± hubs:



Because the product counter needs to add and subtract, its Carry Exit hub is wired to its Carry Entry hub:

The positioning of the multiplicand for transfer to the product counter is governed by the Shift Unit.



Progress of the multiplication is controlled by the multiplier in counter 4: each digit of the multiplier, in turn, beginning with the units position is brought to 0 by repeated addition (if the multiplier digit is 6-9) or subtraction (if the multiplier digit is 1-5) of a 1. Thus the multiplier counter is ultimately reset to 0. Multiplier positions containing 0 are skipped without loss of time. Only in "correction cycles", in which 10 times the multiplicand is added, does the multiplier counter not receive a 1 to be added or subtracted. When the product counter adds the multiplicand, this 1 is subtracted from the multiplier counter; when the multiplicand is subtracted, the 1 is added. Thus the product is built up at the same time as the multiplier counter is reduced to zero.

The diagram below shows, in detail, the cycle sequence during the multiplication.

Since multiplication cycles cannot be made to cease until after the end of the multiplication cycles in which the condition for multiplication end is detected, it follows that at least one more multiplication cycle must take place after this condition arises. The overall number of machine cycles (C) needed for a particular multiplication can be calculated from the formula:

$$C = \frac{N + 3}{3}$$

where N is the number of multiplication cycles required for the multiplication proper, obtained from the table given earlier. The remainder after this division should be ignored.

Mult. Cycle	Multiplier (Counter 4) before and after each M-cycle	Product (Counter 8) before and after each M-cycle	Shift Unit
1	273 - 001 = 272	0 + 1234 = 1234	SHIFT EXIT 1 … 1 2 3 4
2	272 - 001 = 271	1234 + 1234 = 2468	
3	271 - 001 = 270	2468 + 1234 = 3702	
4	270 (- 000) = 270	3702 + 123400 = 127102	SHIFT EXIT 1 … 1 2 3 4
5	270 + 010 = 280	127102 - 12340 = 114762	SHIFT EXIT 1 … 1 2 3 4
6	280 + 010 = 290	114762 - 12340 = 102422	
7	290 + 010 = 200	102422 - 12340 = 90082	
8	200 - 100 = 100	90082 + 123400 = 213482	SHIFT EXIT 1 … 1 2 3 4
9	100 - 100 = 000	213482 + 123400 = 336882	

Counter Read in Check

The print unit of the IBM 3000 prints zeros only if the particular print positions receive zero impulses.

In contrast to this, counters do not need to receive zero impulses in order to operate correctly. In other words, it is not strictly necessary to punch zeros in a field. This may be used to advantage if large, round numbers have to be punched frequently, because then the remainder of the field, after the last significant digit, or the whole field if the amount is zero, can be skipped when punching.

On the other hand, there is an advantage in punching every column of a field as a matter of course: then there exists the possibility of checking the punched cards being processed for erroneous blank columns by means of the Counter Read In Check feature. This check can be instituted for each individual counter by jackplugging a switch:

BK-BL/25-36

The unit checks any counter with its check switch wired to ensure that all positions of the counter receive a digit impulse (9-0) whenever that counter is read in. If any of these positions do not receive a digit impulse at this time, the machine stops at the end of the cycle, with the Test lamp flashing.

To recommence operations the Start key must be depressed twice (or held down for slightly longer than the first cycle):

The first key depression extinguishes the Test lamp. The second key depression re-starts the machine.

When a read in check is required without stopping the machine, the NO S (No Stop) switch, to the left of the 12 check switches, should be jackplugged. The Test lamp then only flashes once, briefly, in the cycle in which the error occurs.

The BC (Blank Column) hubs AI-AJ/16

emit an A impulse whenever the Counter Read in Check detects a blank column. This impulse can be used to print an Oblique (/) in a numeric print position or to control any other machine function, with the aid of a selector.

Since Counter Read in Check can be wired for each counter as desired, it is recommended that it be wired for all counters with the exception of those which are to be read in from card fields in which zeros are not all punched.

If the counter reading in is larger than the corresponding card field, the unused senior positions of the counter should be wired from the 0 of the digit emitter. A similar precaution applies in counter total transfer if the receiving counter is of larger capacity than the emitting counter: here, the unused senior positions should be split-wired from the senior position of the emitting counter.

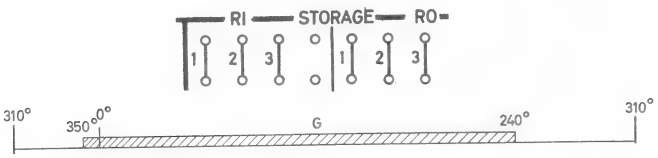
WARNING:

The upper hubs of these twelve switches are exit hubs in every cycle in which the corresponding counter is read out - because of this they must under no circumstances be wired to any hub other than the common hubs immediately below them, as otherwise the counter contacts will be damaged. However, this connection may be selected, if for example Counter Read In Check is not required in every cycle. The connection must not, in this case, be broken by selectors between 0 and A impulse times.

When the counter read in check is not being used, the lower common hubs can be impulsed to stop the machine. For this purpose a (selected) card cycle or program step impulse should be wired to these hubs. The machine will stop at the end of this cycle, with the Test light flashing.

Storage

The IBM 3000 is fitted with 30 positions of storage capable of storing alphabetic or numeric information. Each 10 positions of storage are grouped to form a storage unit which can be controlled to read in or read out information.



Each storage position can accept a digit, an alphabetic character, a symbol or any other combination of punches (multiple punching in one column for control purposes). When a storage unit is read in its previous contents are automatically reset. If Storage Read Out and Storage Read In are controlled simultaneously, the storage emits its contents, resets and accepts the new information, all in the same cycle.

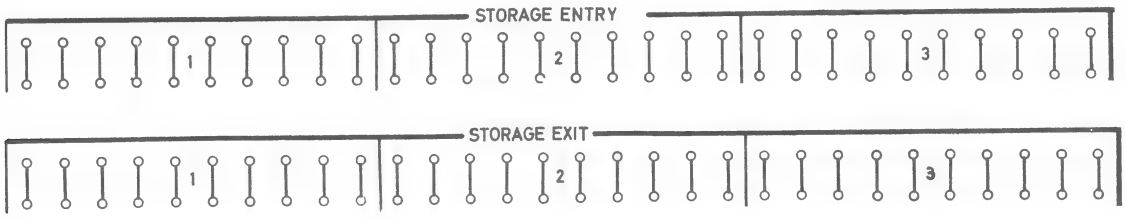
Double Entry hubs and double Exit hubs are provided for each of the 30 storage positions. These hubs only accept (or emit, as appropriate) when the corresponding Storage Read In (or Read Out) hubs are impulsed. The storage segments rotate only when one (or more) of these 6 sets of pick up hubs is impulsed with a long cycle impulse (the All Cycles impulse cannot be used), and then the segments of all three storage units rotate.

If the machine is switched off while idling, the contents of storage are retained. Nevertheless, it is recommended that the information be read in anew (or the storage contents checked) when the machine is again switched on, if this same information is to be used over a long period of time (for example, a discount rate).

Storage cannot be used to hold factors for multiplication because storage impulses, unlike counter impulses, cannot be emitted at the three-times-normal rate.

Some of the many applications of storage are outlined below:

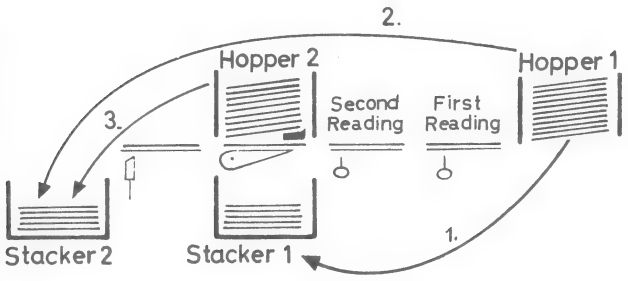
a) Storing information to be printed at the head of successive forms, for example, a name and address which is to be repeated on each form of a group
b) Increasing the column capacity of a card for detail information by storing an address, description or the like from a previous card and printing it from storage.
c) Storing alphabetic or numeric data to be printed on the same line as detail information from a card.
d) Storing information which is to be transferred to a Summary card.
e) Storing group identification
f) Storing headings so that list headings can be printed on plain paper from reels or on unprinted continuous stationery.
g) Increasing counter capacity for accumulating a final total. Two program steps at each group change are required for this: in the first program step the running total is read out from storage and added into the counter. In the second program step the new running total is again transferred to storage, leaving the counter free to accumulate only each group total.
h) All information punched by the IBM 3000 must come from storage (or counters). Only for duplicating can data come directly from card reading.
i) Storage can be used to achieve a cycle delay by impulsing Storage Read In and Read Out at the same time. Then, data entered into Storage Entry will be available one cycle later from Storage Exit.
j) Similarly, with the aid of storage, data from one card can be printed in two successive lines by taking a program step, in which the storage is read out, after every card cycle.



The IBM 3000 is an Accounting Machine which combines many functions in its construction. It is equipped with:

2 card hoppers
2 reading stations
1 card selecting station
1 punch station
2 stackers.

The following illustation shows the 3 possible card paths:



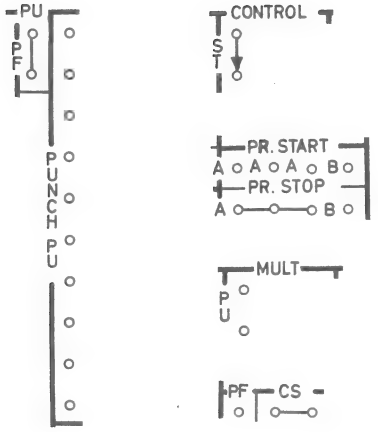
1) Cards from the first hopper normally pass through the first and second reading stations and are stacked in stacker one.

2) Cards from the first station can, after passing second reading, be directed through the card select station to the punch station to stack in stacker two.

3) Cards from the second hopper pass through the punch station and are stacked in stacker two.

These three card paths can be combined to give 6 possible modes of operation (1; 2; 1 + 2; 1 + 3; 2 + 3; 1 + 2 + 3). Thus only one of the theoretically possible combinations is omitted - it is not possible to use card path 3 alone, with no cards in the reading unit (see "Start and Run Conditions").

For any desired mode of operation, certain operating keys must be depressed and hubs on the control panel wired. The following keys and hubs are concerned with card transport:



In the following, only those functions which are directly concerned with card transport are described.

Key No. 6 Card Select

This key, when depressed, controls the following functions:

1) It makes the CS (Card Select) hub operative.

2) It affects the start and run conditions (see below).

3) When one of the eleven sets of punch pick up hubs (Punch PU 1-10 or PF PU) is impulsed, a card is not automatically fed from the punch hopper. To achieve this, the PF hub (Punch Feed - G 19) must also be impulsed, with a cycle impulse.

4) The card transport mechanism of the punch unit operates until a card from either hopper is just about to enter the punch station. The card then remains in this position until one of the eleven punch pick-up hubs receives an impulse.

KEY RESET	CARR SWITCH	FORM STOP SUPPR.	SWITCH 1	SWITCH 2	CARD SEL	SUM P REPR	PROGR START SUPPR.	TAB	KEY RESET
					6	7	8		

AUX START	FINAL TEST	START IDLING	STOP FUSE
11		13	14

Key No. 7 Sum P and Repr

(Summary Punching and Reproducing)

This key, sometimes referred to as the "Punch" key, affects the start and running conditions of the machine (see below). It must always be depressed if cards are to be fed from the punch hopper. If, at the same time, key No. 6 is depressed, the PF hub must receive a cycle impulse in order to feed cards from this hopper.

It should be noted that the SUM P and REPR key should not be depressed if cards from the reading unit only are to be punched; alternatively, there must be cards in the punch hopper.

Key No. 8 Prog Suppr

(Program Suppress)

The only effect that this key has on card transport is that it renders the Program Start hubs inoperative, and therefore, when it is depressed, card feeding is not interrupted by an impulse to one of the Program Start hubs.

Key No. 11 Aux Start

(Auxiliary Start)

This key only affects card transport under feed interlock conditions and is otherwise inoperative.

Key No. 13 Start

This key is used to set the machine in operation, provided the start and run conditions are satisfied (see below). In a feed interlock, this start key is ineffective.

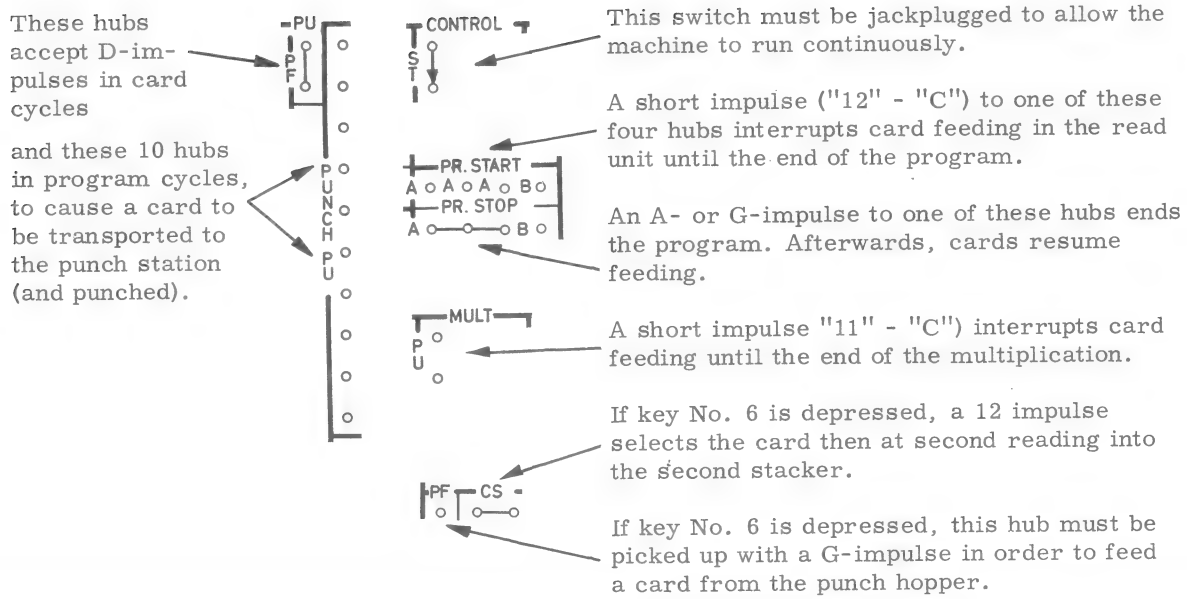
Key No. 14 Stop

Pressing this key interrupts card transport in the reading unit; a program or a multiplication will be completed before the machine stops.

The function of the hubs associated with card transport is shown in the summary below.

The effect of the Control ST, PR Start, PR Stop and Mult PU hubs on card transport is made clear in this summary. The other functions of these hubs are described elsewhere.

However, an accurate knowledge of the Punch PU, PF PU, CS and PF hubs in association with keys 6 and 7 is of great importance for the understanding of all wirings in which cards are to be punched.

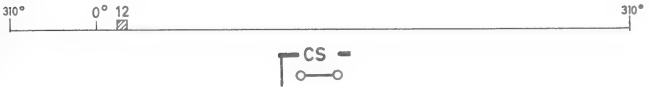


PUNCH PU 1-10 S-AB/14

PF PU (Punch Pick-up - Card Feed cycles) S-T/13

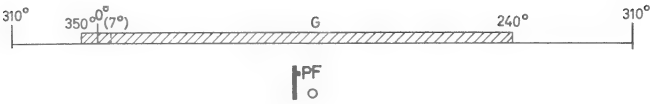
The Punch PU 1-10 hubs must only be wired from the Punch Couple hubs directly to the right of them, and the PF PU hub from the CF hub (J / 19-21). Only one of these eleven punch pick-up hubs is operative in any given working cycle and, in this cycle, can receive a D-impulse to cause card movement in the punch unit. In this way, a card just ahead of the punch station will be transported through the punch station (and punched). At the same time, if key No. 6 is not depressed and key No. 7 is, a new card will be fed from the punch hopper to just before the punch station.

CS (Card Select) J/20-21



This hub is only operative if the Card Select switch (No. 6) is depressed. If it receives a 12 impulse in a card cycle, the card then at the second reading station will not be stacked in the first stacker but will pass through the card select and punch stations to the second stacker. It should be noted that this hub will only accept a 12 impulse (from the emitter, for example) in program cycles if no card is to be fed from the punch hopper. The hub can therefore be wired from the emitter only if cards from the reading unit alone are to be punched.

PF (Punch Feed) J/19



This hub is only operative when the Card Select key (No. 6) is depressed. It must then be impulsed with a cycle impulse when a card is to be fed from the punch hopper. However, if the CS hub is impulsed in the preceding working cycle, a card will not be fed from the punch hopper, so that two cards can not reach the punch station simultaneously.

The machine is so wired internally that no damage can result from two cards from the two card feeds coming together. This is of some importance because the relationships in complicated wirings are often difficult to see.

In contrast to this, the machine has no safeguards against damage caused by, for example, a number of cards from the read unit being directed through the card select station and a connection to one of the punch pick-up hubs being forgotten. Cards coming from the reading station will then not be transported beyond the card select station and damage to the cards and to the machine can result.

The following rule should therefore be observed:

WARNING:
IN ALL OPERATIONS INVOLVING CARD SELECTION, CHECK THAT THE "PUNCH PICK-UP" HUBS ARE WIRED.

Summary

For all operations in which punching is to take place one or both of the SUM P or REPR and Card Select switches must be depressed.

Distinction should be made between actual card movement through the punch unit and feeding of cards into the punch unit; thus a card transport operation in the punch unit does not automatically imply card feeding from the punch hopper.

The card transport rolls of the punch unit operate under the following conditions:

1) When the CARD SEL key (No. 6) is depressed, the punch transport rolls operate automatically until a card from either the first or the second hopper is just about to enter the punch station.

2) A card about to enter the punch station will be transported through the punch station and punched, by means of a D-impulse to one of the eleven punch PU hubs, provided that there is also a card at the first or second reading station.

3) When only key No. 7 is depressed, the first card from the punch hopper will be automatically transported to just ahead of the punch station.

4) When there are no further cards in the machine, other than the last card about to enter the punch station, pressing the Start key is sufficient to cause this card to be stacked.

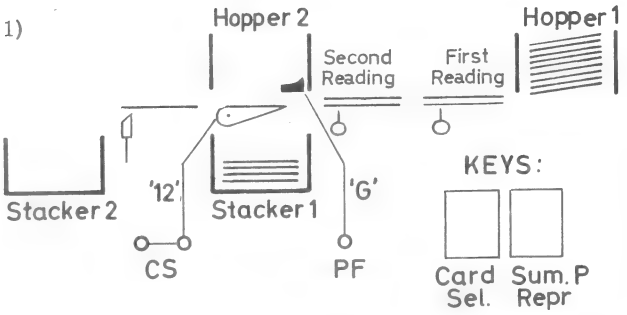
If the CARD SEL key (No. 6) is not depressed, a card will be fed from the punch hopper every time the punch transport mechanism operates; that is, when one of the eleven punch pick-up hubs receives an impulse.

This automatic feed will be interrupted as soon as key No. 6 is depressed, because then cards from the read unit can pass through the punch unit and so the card bed must be kept free.

When, in combined operations of this kind, cards are to be fed from the punch hopper, the PF hub must be impulsed with a cycle impulse at least one cycle before this card is to be punched. The PF hub is only operative, however, if in this cycle a card transport action occurs, either automatically or by means of a D-impulse to one of the eleven punch pick-up hubs, and there is no card from the read unit in the card select station.

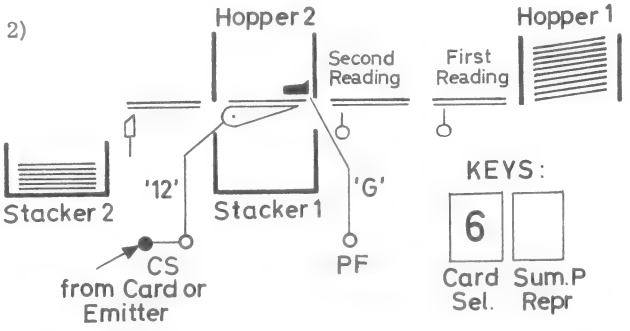
The six different modes of operation of the machine are again summarized below:

1)



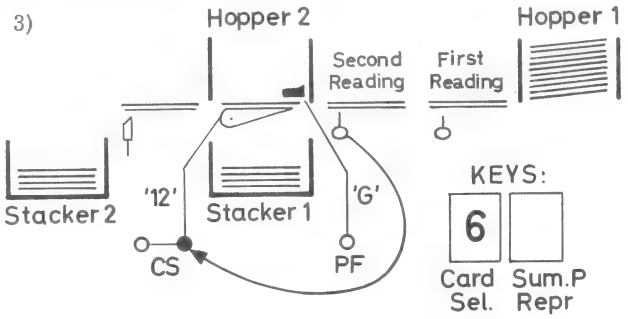
card paths	1
applications	normal accounting machine operations
wiring examples	Nos. 1 - 9

2)



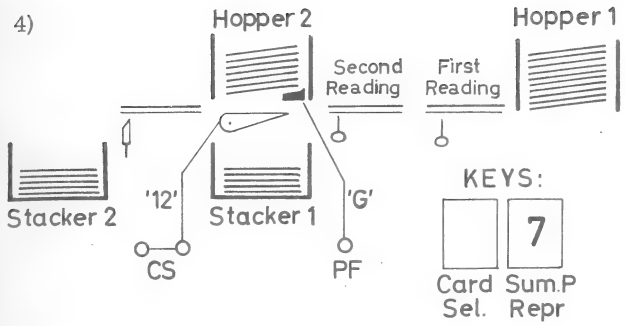
card paths	2
applications	calculator punch, punching (with or without printing)
wiring examples	Nos. 10, 12-14, 16, 17

3)



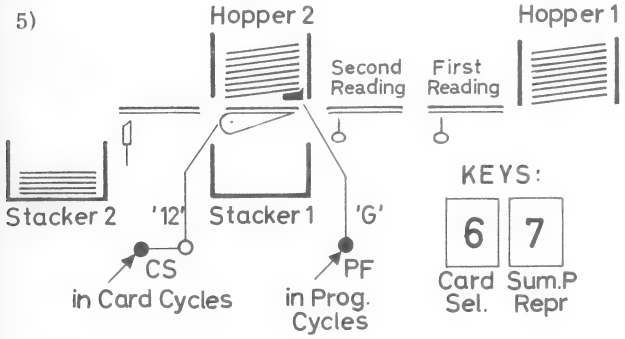
card paths	1 2
applications	all operations as for 1) and 2), however, with selection of master cards
wiring examples	Nos. 18, 19

4)



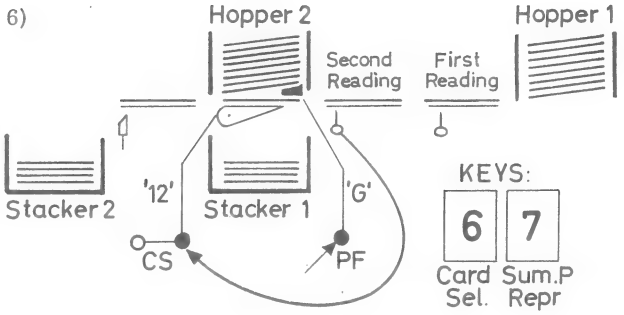
card paths 1 3
applications duplicating, counter controlled gang punching without merging of master cards, punching of summary cards in accounting machine operation
wiring examples Nos. 15, 20, 21, 23

5)



card paths 2 3
applications all operations as for 2) with the addition of summary punching, counter controlled punching with merging of master cards
wiring example No. 22

6)



card paths 1 2 3
applications Calculator printing with summary cards and selection of address cards
wiring example No. 24

Start- and Run Conditions

When the main line switch is turned on, starting of machine operations is dependent upon so-called start and run conditions. There are three possible situations:

1) The Start key is inoperative if the start conditions are not satisfied or a feed interlock occurs.

2) When the start conditions are fulfilled but the run conditions are not, the machine will take only one card cycle for each depression of the start key. If a program is initiated at the same time, program cycles will occur until Program Stop is impulsed.

					 6 = Card Select 7 = Punch			
1	x	x	x	x	-	-	+	+
2		x	x	x	-	-	1	+
3	x		x	x	1	+	-	-
4			x	x	+	+	-	-
5	x	x		x	-	-	1	1
6		x		x	-	-	1	1
7	x			x	1	1	-	-
8				x	1	1	-	-
9	x	x	x		-	-	1	1
10		x	x		-	-	1	1
11	x		x		1	1	-	-
12			x		1	1	-	-
13	x	x			-	-	-	-
14		x			-	-	-	-
15	x				1	1	1	1
16					1	1	1	1

x = Card at corresponding station

\+ = Run

1 = Single Cycle

\- = Start Key inoperative

3) When the run conditions are fulfilled - it is relevant here that the Control ST switch (C-D/19) be jackplugged - a single depression of the Start key is sufficient to cause the machine to run automatically. These start and run conditions depend in their details on the particular operation, in particular, on which of keys 6 and 7 (Card Select, SUM.P., REPR.) is depressed and at which stations of the machine cards are present.

These conditions are developed graphically in the accompanying table.

The following rules can be derived from this table:

1) The machine can run continuously only when there are cards in the first hopper and at the second reading station (cases 1 - 4).

2) From the point of view of run control it is only significant whether or not cards are present at either or both of the reading stations (however, see Feed Interlock and Auxiliary Start).

3) When key 6 is depressed, the presence of a card at the punch station is irrelevant (cases 1 and 4, in contrast to 2 and 3, because in operations involving card selection cards from both units may pass through the punch station).

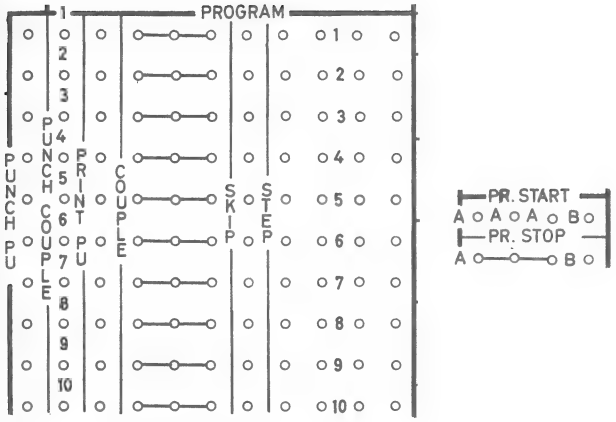
4) Key No. 7 must be depressed if cards are in the punch hopper (cases 1 and 2) and must not be depressed if the punch hopper is empty (cases 3 and 4).

5) When, in the course of an operation, the last card is fed from the first hopper, the machine stops and cases 1 - 4 become, as a rule, cases 9 - 12. The machine can thus be restarted and the cards in the machine run out.

6) When, during an operation, the last card is fed from the punch hopper, the machine stops and cases 1 and 2 become cases 3 and 4. In contrast to the above, the Start key is inoperative until new cards are inserted or key No. 7 is restored.

7) Cases 5-12, 15 and 16 are concerned with card run in and run out cycles, in which the Start key is always effective for only one cycle.

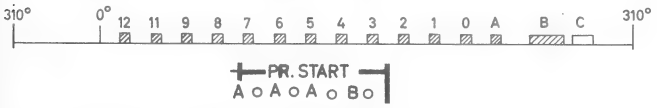
8) Cases 13 and 14 show that the punch unit can not operate if there are no cards in the read unit.



With the aid of the program unit it is possible, after every card, after certain cards (with the aid of identifying punches) or on a change of control number, to interrupt card feeding and to take one or more program cycles.

In the program any desired machine functions, such as total transfer, multiplication, counter reset, storage readout, printing or punching of results etc., may take place, either simultaneously or in successive program cycles.

PR START A (Program Start A) (I/22-24)
PR START B (Program Start B) (I/25)

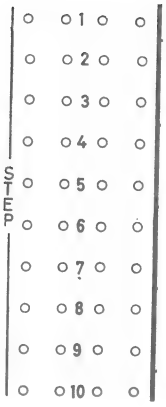


In order to start a program one of the three PR START A hubs or PR START B hubs must be impulsed with one of the short impulses: 12-0, A, B or C. Tape Exit impulses, if they occur between 0 and 310°, may be used. Impulses which are also available during idle cycles (for example those from the emitter) must not be wired directly to Program Start and long impulses (for example cycle impulses) must never be used for this purpose.

The three PR START A hubs are independent so that they do not cause back circuits.

The Program Start hubs are inoperative if the Program Start Suppress key is depressed.

PROGRAM STEP 1 - 10 (S-AB/21-24)

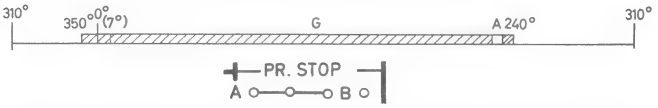


As soon as a program is initiated card feeding is interrupted from the end of the corresponding cycle. The machine then takes program cycles until (in the last desired program cycle) PR STOP A or PR STOP B receives an impulse. Following the program the machine feeds cards.

There are 10 Program Step rows which emit program cycle impulses one after the other in successive program cycles. Four independent hubs, which may be used for the control of any desired machine function, are associated with each program step row.

If Program Stop has not been wired by the time Program Step 10 has emitted, the first program step row will emit in the following program cycle and the sequence will repeat until Program Stop A or B is picked up.

PR STOP A (Program Stop A) (J/22-24)
PR STOP B (Program Stop B) (J/25)



The Program Stop hubs can be impulsed with a Program Step impulse or an A-impulse (CI, CCI, Carry Exit). This will cause the program to end and the machine to resume card feeding. Only one of the two Program Stop hubs, A or B, is operative at any one time; if PR START A and B (in a card cycle) were picked up simultaneously, in the program PR STOP B is operative.

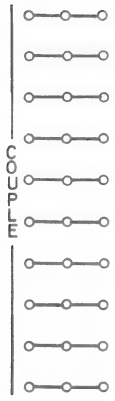
If PR START B was picked up in the course of a program, PR STOP B is effective from the following cycle.

If PR START B was picked up and the Control First Card switch is wired, the First Card A and B hubs emit in the first card cycle after the program; if only PR START A was picked up, only the First Card A hub emits.

Program Stop can also be impulsed during a card cycle (with a Card Cycle impulse or an A-impulse) if the program picked up at the same time is to be suppressed. In this case Program Start must be picked up with a digit impulse 12-0 or with an A-impulse; if the pick up was by a B- or C-impulse the program will not be suppressed.

If, in a card cycle, only Program Stop A is impulsed and the Control First Card switch is wired, the First Card A hubs emit a cycle impulse in the next card cycle. If the machine is tabulating, this cycle will also be a print cycle (this is one of the possibilities of achieving selective list).

PROGRAM COUPLE 1 - 10 (S-AB/17-19)



Each Program Step row has associated with it three common Program Couple hubs. These emit, in the same program cycle, an impulse slightly longer than the normal Program Step impulse.

The Program Couple hubs have three distinct functions.

1. If the Program Couple impulse is wired to the Pick up hub of a co-selector the co-selector transfers for the corresponding program cycle. In this way additional Program Step impulses can be obtained by wiring the All Cycles impulse through this selector.

2. If two or more Program Couple hubs are wired together, the corresponding program step rows emit in the same program cycle. This facility may be used if, for example, more than four independent program cycle impulses are required in the same program cycle and not all 10 program steps are in use. If two non-consecutive program couple hubs are connected, the intervening program steps rows are skipped. Program couple 10 is an exception to this: if this hub is connected to any one of the Program Couple 1 to 8 hubs, the intervening rows are not skipped (See Wirings 7 and 8).

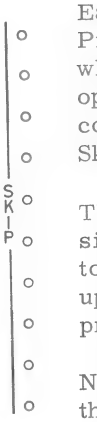
   This wiring can, in theory, be wired through selectors - if, for example, the couple hubs are not to be connected together in every program. If this wiring is selected, great care must be taken to avoid breaking the connection during the impulse time. For this reason, the Program Skip hubs are usually used for selective skipping of program steps (see Wirings No. 10 - 12)

3. The Program Couple hubs are also used to cause a print cycle to take place in that program step by wiring this impulse into the Print Pick-up hubs immediately to the left. It should be noted that if two program couple hubs are connected together, only the upper Print Pick-up hub is effective.

Note: Program Couple hubs must not receive back circuits (undesirable impulses) in either card cycles or program cycles, otherwise incorrect machine operation will result.

PROGRAM SKIP 1 - 10 (S-AB/20)

PROGRAM SKIP 1 - 9 (S-AA/20)



Each Program Step row has an associated Program Skip hub which emits a B-impulse when the corresponding program row is in operation. If two program step rows are connected together, both their Program Skip hubs emit.

This impulse may be used to control any desired machine function - for example selector pick-up or drop out, multiplication pick-up, initiation of a carriage movement or a program skip or making a zero check.

Note: Program Skip hubs do not emit in the cycle in which Program Stop is wired.

The Program Skip 1 - 9 hubs are also in certain circumstances entry hubs for zero, A, B and C impulses.

If a program skip hub receives, in the course of a program, an impulse (for example from one of the program skip hubs above) then the corresponding program step row together with all intervening program step rows will be skipped. The next program step row to operate is that which follows the suppressed row. In other words: if Program Skip 1 is wired to Program Skip 8, Program Step rows 2 to 7 are skipped and Program Step row 8 follows directly after Program Step row 1 (see wiring No. 10). Program skip can also be wired selectively (see wiring No. 12).

The Program Skip 10 hub is an exception in that it is not an entry hub: Program step row 10 can not be suppressed. If, for example, Program Skip 1 is wired to Program Skip 2, the D-impulse emitted in program step 1 is inoperative. The D-impulse emitted in program step 10, however, (provided Program Stop has not been impulsed), causes Program Step row 2 to follow Program Step row 10.

PUNCH COUPLE 1 - 10 (S-AB, 15)

Each Program Step row has an associated Punch Couple hub, which emits a D-impulse at the beginning of the corresponding cycle. This impulse is normally wired to the Punch Pick up hub immediately to the left of it. It can also be used to control various machine functions, such as selector pick up and drop out.

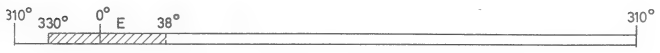
If two program step rows are coupled together, only the upper Punch Couple hub emits (see Wiring No. 4 - 7). There is one exception on this, in the case of Program Couple 10 being connected with one of the others (See Wirings 7 to 9).

Note: Care must be taken to avoid back circuits to the Punch Couple hubs during program cycles, otherwise incorrect machine operation will result. If one of the Punch Couple hubs receives an impulse during card cycles, the Program Couple hubs of the same row emit an impulse which begins immediately and lasts until the end of that particular cycle (310°). A program is not initiated in this case and likewise the Program Step exit hubs do not emit in card cycles. A co-selector can be picked up with the impulse from a Program Couple hub, without requiring one of the positions of the co-selector to be used for a holding impulse. This may be useful when the program cycle impulses available on the particular program step are insufficient and when selector capacity is limited. (Wiring No. 19).

PUNCH PICK UP (S-AB/14)

These hubs are operative in the appropriate program cycles. If there is a card at the punch station, a Punch Pick-up hub will accept the impulse from the Punch Couple hub to the right of it to cause that card to be punched.

PRINT P U (S-AB/16)



These hubs are only operative in the appropriate program cycle and are normally wired from the Program Couple hubs to the right of them if printing is required during a program. In theory, the shorter E-impulse from the RX hubs is sufficient; this is more suitable for selection if printing is not required in every program.

There are some further hubs, directly concerned with the program, which are not dealt with in this chapter:

Drop Out Impulse PE (I/19-21)
Control FC (C-D/21)
First Card A, B (R/20-24)
Carriage AC, AP, BC, BP (Q/10-13)
* (Program Cycle Symbol) (AG-AH/16)
PROG H (Program Hold Impulse) (AJ/21-22)
FCC HOLD (First Card Cycle Hold Impulse) (AJ/17-20)

Program Wiring Examples

The following examples do not give the complete wiring for a particular application. They only show the wiring necessary to illustrate the use of the particular program feature. Standard wiring, such as Run Control and Pick up of Program Start, for example, are not shown.

Figure 1 shows the normal program pick up with one program level.

1. Program level A is picked up with a B-impulse from the comparing exit on a change in control number.
2. The program consists of 3 steps.
3. Program Stop A is impulsed in the third program cycle.
4. Program Skip 3 does not emit in the last program cycle.
5. In the first card cycle after the program the comparing selectors are dropped out with a D-impulse from the PE hubs.

Figure 2 shows the program wiring for two program levels A and B

1. The control number for the minor group (level A) is punched in columns 17 and 18 and is wired into Comparing Entries 1 and 2 of latch selectors 17 and 18.
2. The control number for the main group (level B) is punched into columns 15 and 16 and is wired into the first and second comparing entries of latch selectors 15 and 16.

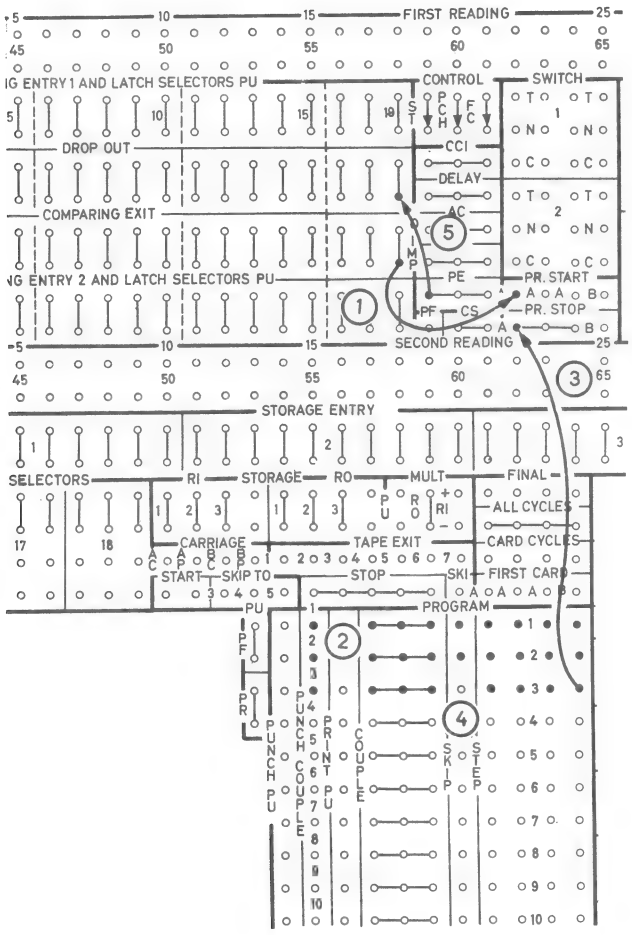


Fig. 1

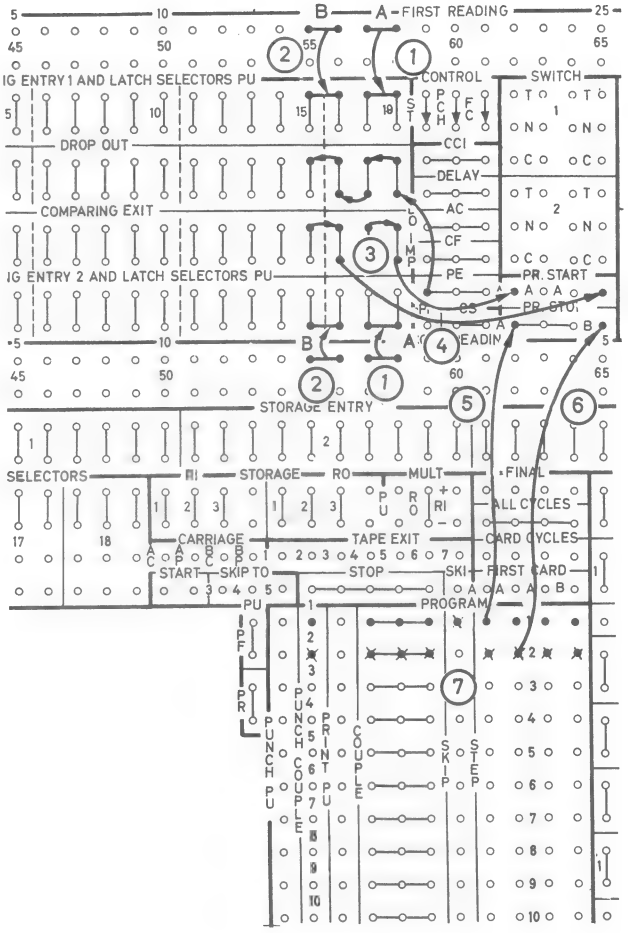


Fig. 2

3. Program start A is impulsed when the minor group control number changes.

4. Program start B is impulsed when the major group control number changes.

5. In program level A, Program Stop A is operative and allows only one program cycle to take place.

6. In program level B, Program Stop B is operative and allows two program cycles to take place.

7. Program Skip 1 emits only in program level B. Program Skip 2 does not emit in either case.

Figure 3 shows three levels of program control (minor, intermediate and major groups). A minor group change allows only a single step program to take place; an intermediate group change allows two and a major group change three program steps to take place.

1. The control numbers are wired from First and Second Reading into Comparing Entries 1 and 2.

2. When the minor group control changes, Comparing Exits 12 to 15 emit a B-impulse which is wired to Program Start A.

3. When the intermediate or major group control number changes, Comparing Exits 6 to 11 emit a B-impulse which is wired to Program Start B.

4. For a minor program, Program Stop A is operative, so that only one program step takes place.

5. The major group control number is compared in latch selectors 6 - 8. If the major control break has not occurred these three selectors are normal during a program, so that the Program Step impulse in the second program cycle can reach Program Stop B. This causes an intermediate level program to stop after two program cycles.

6. With a major control break, at least one of latch selectors 6 - 8 will be transferred so that connection 5 is interrupted. This permits three cycles to occur in a major program. Program Stop B can thus be wired directly from one of the exits of Program Step row 3.

7. The comparing selectors are reset by a D-impulse from the PE hubs in the first card cycle after a program.

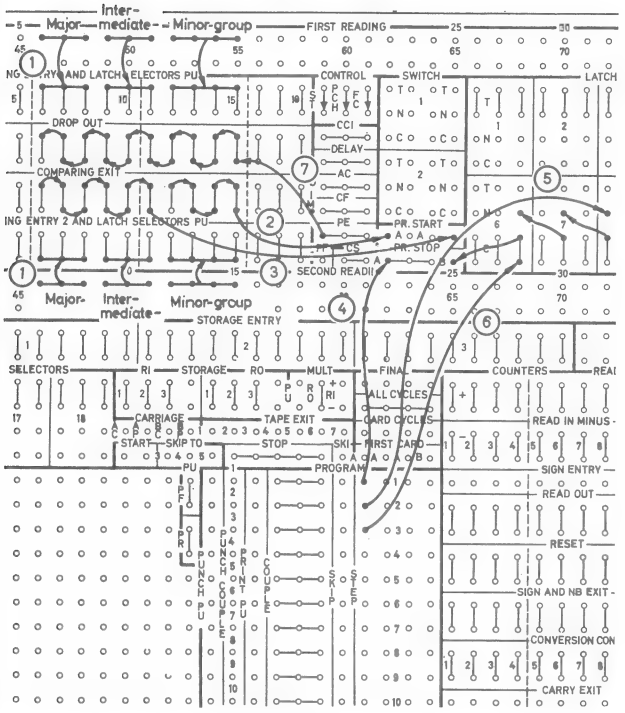


Fig. 3

In the following figures 4 - 11 only the program step row control wiring is shown, not however, program pick up or the wiring of program stop. It is assumed that a program can consist of a number of steps and that the program sequence may be repeated a number of times until, in a certain step, conditions are satisfied and an impulse (for example a carry impulse) reaches Program Stop.

In figure 4, Program Couple 1 and 2 are connected together, so that Program Step rows 1 and 2 emit together in program steps 1, 10, 19 .... and the loop consists of 9 steps. It should be noted that the Punch Couple 2 hub does not emit.

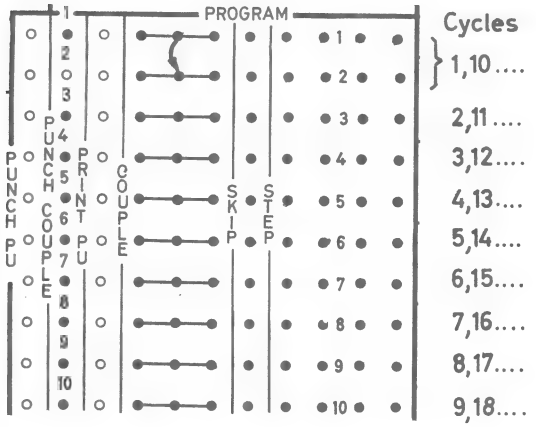


Fig. 4

In figure 5, the Program Couple 2, 3 and 4 hubs are connected together, so that in program steps 2, 10, 18 and so on 12 independent program step impulses are available. The program loop consists of 8 steps. It should be noted that the Punch Couple 3 and 4 hubs do not emit.

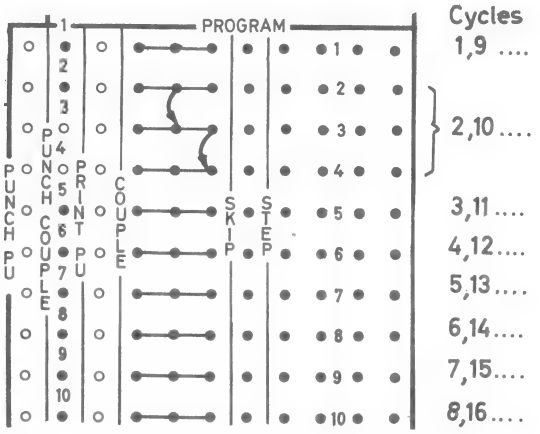


Fig. 5

In figure 6, the Program Couple 1 and 9 hubs are connected together, so that Program Step rows 2 to 8 are skipped. Rows 1 and 9 emit together in odd numbered program cycles. The Punch Couple 9 hub is inoperative.

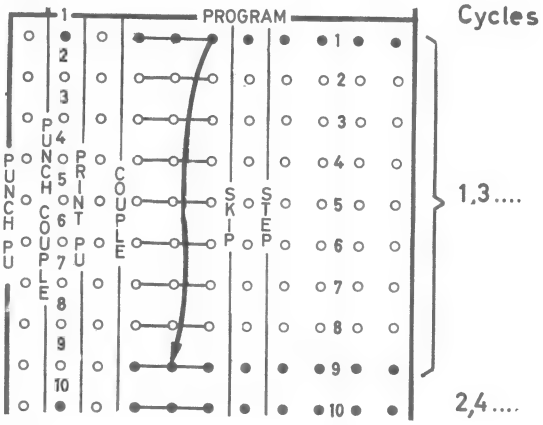


Fig. 6

In figure 7, the Program Couple 1 and 10 hubs are connected together. This shows two exceptional features:

1. The intervening rows are not skipped. The program loop consists of 9 steps.

2. The Punch Couple 1 hub emits only in the first program cycle and in no other; the Punch Couple 10 hub emits in steps 10, 19, 28 ...

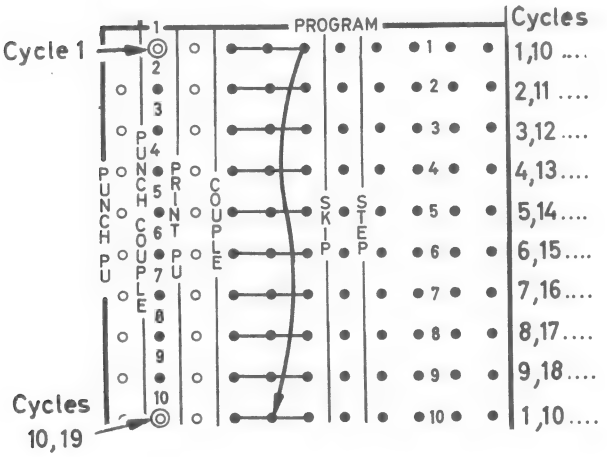


Fig. 7

Figure 8 is almost the same as the preceding figure except that here Program Step Rows 1 to 7 do not repeat.

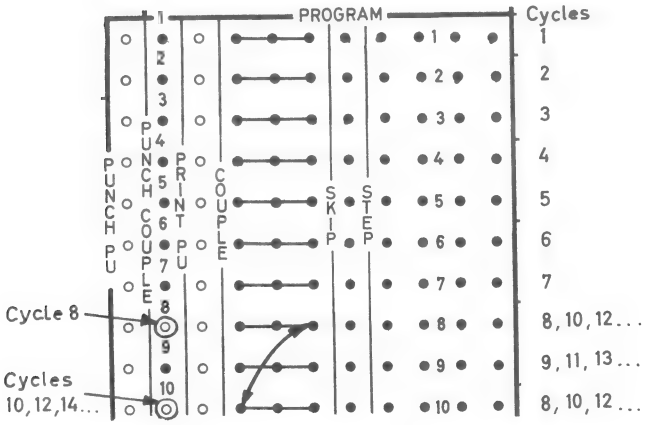


Fig. 8

In figure 9, all Program Couple hubs are connected together. This causes a repetitive program cycle, that is the same program step repeats continuously until Program Stop is impulsed. The same exception is found here: the Punch Couple 1 hub emits only in the first program step; the Punch Couple 10 hub emits from the second program step onwards.

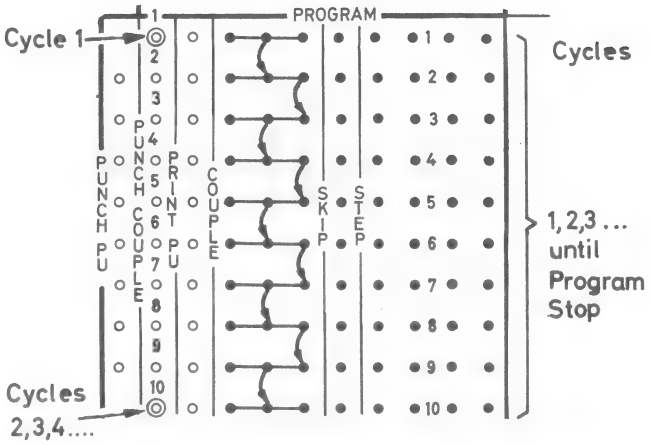


Fig. 9

If this method of achieving a repetitive program cycle is employed (for example for gang punching, counter controlled gang punching and so on) both Punch Couple 1 and 10 must be wired to their respective Punch Pick-up hubs. It should also be noted that the Program Skip hubs do not emit in the last program cycle.

Figure 10 shows the wiring of the Program Skip hubs to suppress program steps. If Program Skip 8 is wired from Program Skip 1, the D-impulse from Program Skip 1 suppresses Program Step rows 2 - 8. In the second program cycle, Program Step row 9 is operative. The program loop consists of three program steps.

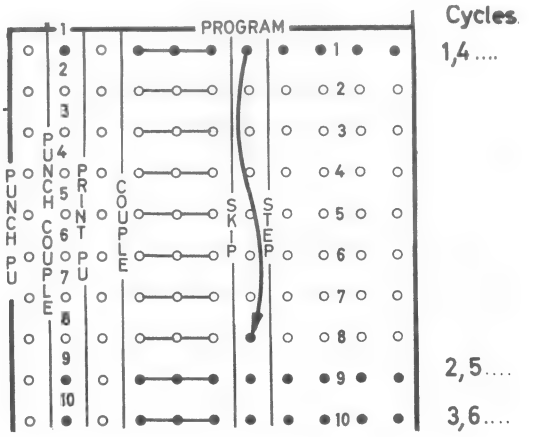


Fig. 10

Figure 11 is essentially similar to the preceding figure, except that here the program loop consists of two program steps. In its effect this wiring corresponds almost exactly to that shown in figure 6. This wiring, however, has an advantage in that it can be selected, if program skip is not required in every program, because here a short impulse (B-Impulse) is concerned. An example of this is shown in the next figure.

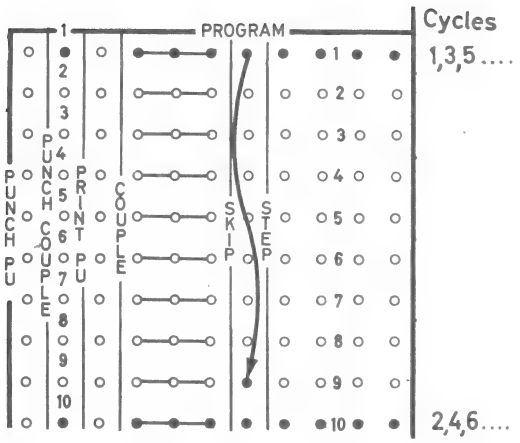


Fig. 11

Figure 12 shows the possibility, by selectively controlling program skip, of obtaining two different program levels without the use of Program Start B.

1. The control numbers of the major and minor groups are wired into Comparing Entries 1 and 2.

2. For a major control break, at least one of the latch selectors is transferred during a program, so that the connection from Program Skip 1 to Program Skip 4 through the Normal side of these selectors is broken. Thus program rows 2 - 9 are not skipped and the major program consists of 10 steps.

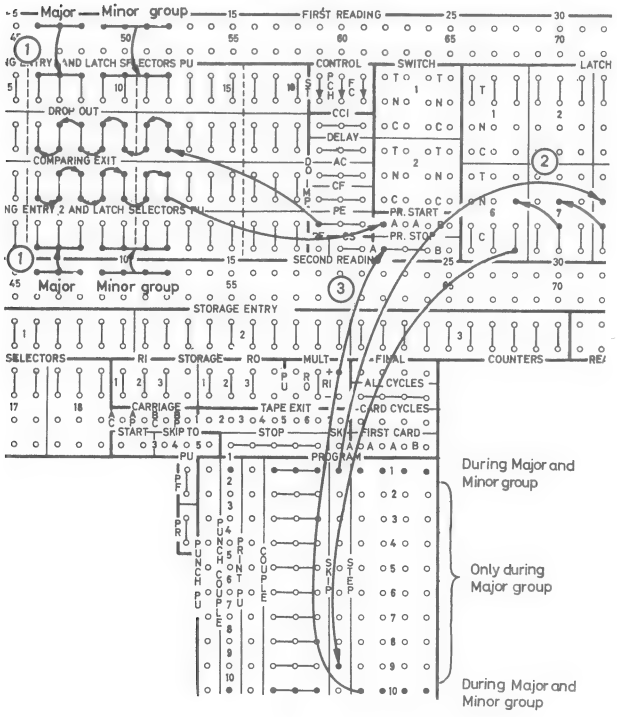


Fig. 12

3. Only two steps are taken in a minor program. Program row 10 is, however, the last in either case, so that Program Stop A can be wired from one Program Step exit hub for both major and minor programs.

In figure 13 is shown the wiring necessary if program row 1 is not to emit in the first program cycle:

1. If the B-impulse from the Comparing Exit is wired simultaneously to Program Start and Program Skip 7, program row 8 will emit in the first program cycle. If in the third step (program row 10) Program Stop is not impulsed, the program will continue with rows 1, 2 etc.. In the tenth program step the Program Skip 7 hub will emit a B-impulse through the Comparing Exit common hubs to Program Start A, but this will have no effect as the program is already picked up.

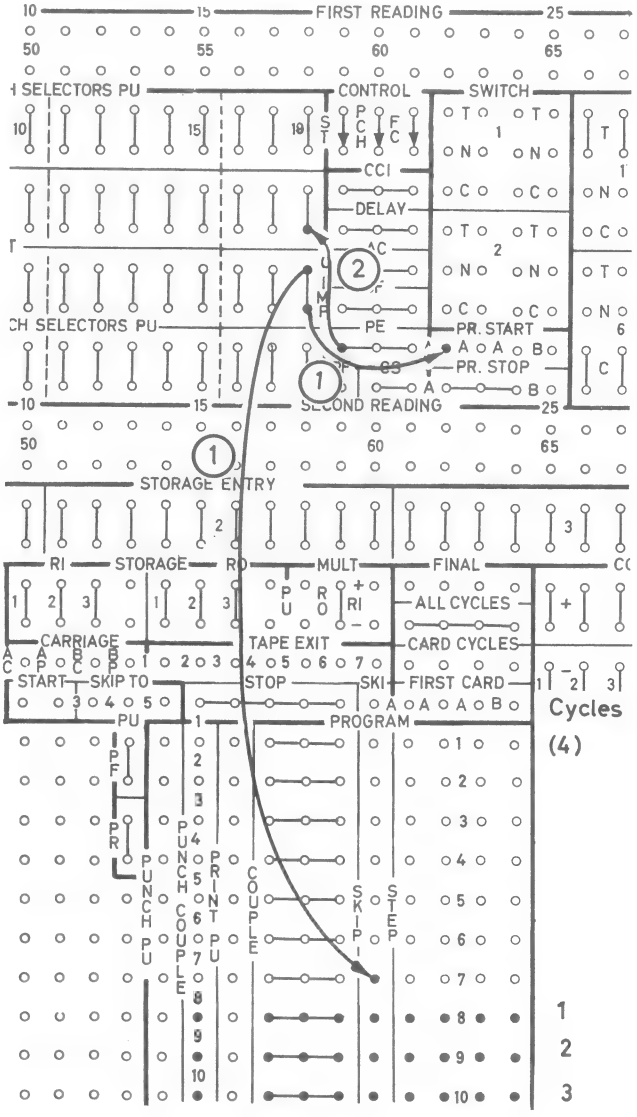


Fig. 13

2. After the program the latch selectors will be dropped out.

Figure 14 shows another method for wiring different A and B level programs.

1. Latch selectors 15 - 18 are used for comparing.

2. Only Program Start A will be picked up on a minor control break and Program Step rows 1 to 5 will emit in succession.

3. Program Stop A is impulsed in step 5. It should be noted that the Program Skip 5 hub does not emit, because this is the last program step, and therefore no back circuit through the Comparing Exit common hubs can affect Program Start B. If this were the case, the First Card B hub would emit in the first cycle after this minor program, which would be undesirable.

4. On a major control break, Program Start B and Program Skip 5 are simultaneously impulsed. Thus the program comences with row 6.

5. The program is ended in the fifth step by an impulse from row 10.

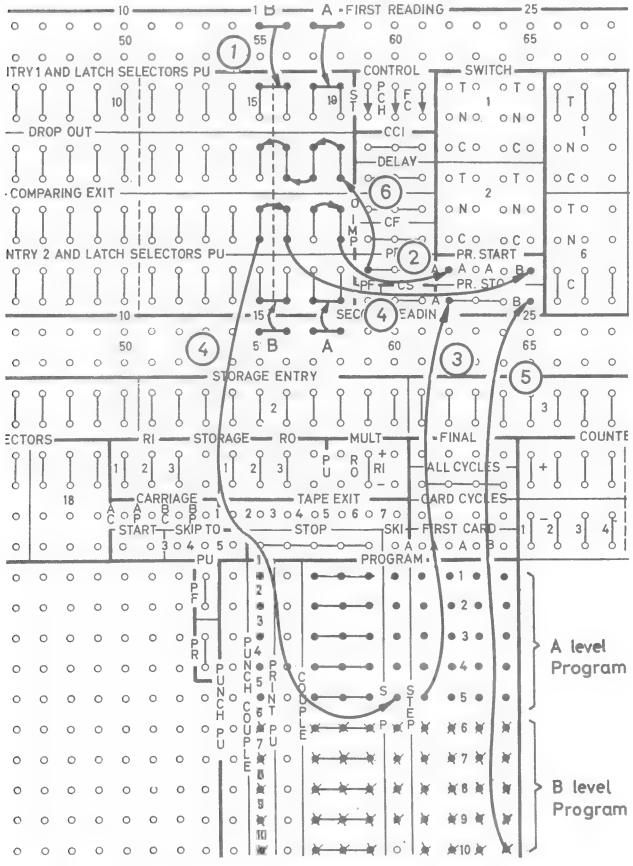


Fig. 14

6. The latch selectors are dropped out with a D-impulse from the PE hubs after each program.

If, in this wiring, Program Start A and B are picked up together, the second program will take place.

In the four following figures different possibilities of achieving repetitive program cycles are shown.

Figure 15 shows the wiring for a program step which repeats until Program Stop is impulsed (with no possibility of suppressing the program for a zero balance):

1. The Program Skip 9 hub constantly receives a B-impulse from Delay. This impulse is only effective, however, if Program Start is simultaneously impulsed.

2. With a change in control number, the Comparing Exit likewise emits a B-impulse to Program Start A, initiating a program which comences with program row 10.

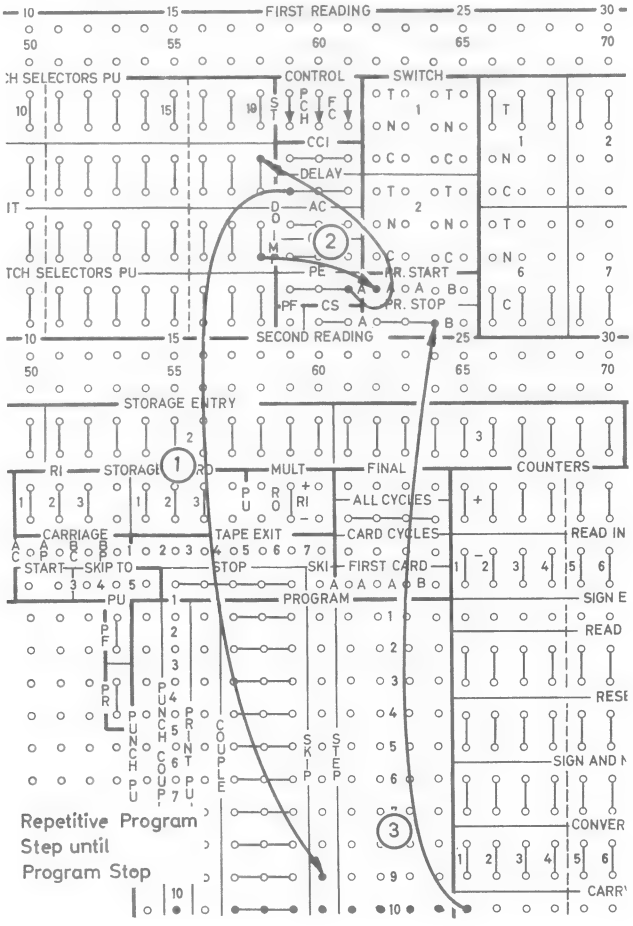


Fig. 15

3. This program step repeats until Program Stop A is impulsed, for example, by an A impulse from the Carry Exit hub of counter 1. The program will then be interrupted. It should be noted that a program initiated by a B-impulse cannot be suppressed (see figure 17 below).

In a complete wiring, counter 1 must be reset at the beginning of the run by means of a Final impulse.

Figure 16 shows the wiring for a program step which repeats until one cycle after a given condition has arisen, in other words until one cycle after the pick up of Program Start B (without the possibility of suppressing the program in the event of zero balance). This example differs from the preceding one only in the wiring of program stop:

1. Program Stop B receives a program cycle impulse in every program step, this is, however, ineffective because Program Start A was picked up and therefore only Program Stop A is operative.

2. If the Carry Exit hub emits an A-impulse and consequently Program Start B is picked up by it, Program Stop B is effective in a subsequent cycle. If the carry impulse is emitted in a program cycle, one further program cycle takes place.

In a complete wiring counter 1 must be reset at the beginning of a run by means of a Final impulse.

Figure 17 shows the wiring for a program step which repeats until Program Stop is impulsed (with the possibility of suppressing a program in the case of a zero balance). If the program is started by an earlier impulse (digit impulse 12 - 0 or A-impulse), it is possible to render the program pick up ineffective by wiring an A-impulse (or cycle impulse) to the Program Stop hub in the same card cycle (see also Wiring No. 22).

1. Program Start A is picked up with an A-impulse from the CCI hub in every card cycle. This connection can also be made through selectors (see Wiring No. 22).

2. The B-impulse wired to Program Skip 9 from the Delay hub is effective in all card cycles (as soon as Program Start A is picked up) and program cycles.

3. Thus the program cycle repeats until Program Stop receives an impulse, for exam-

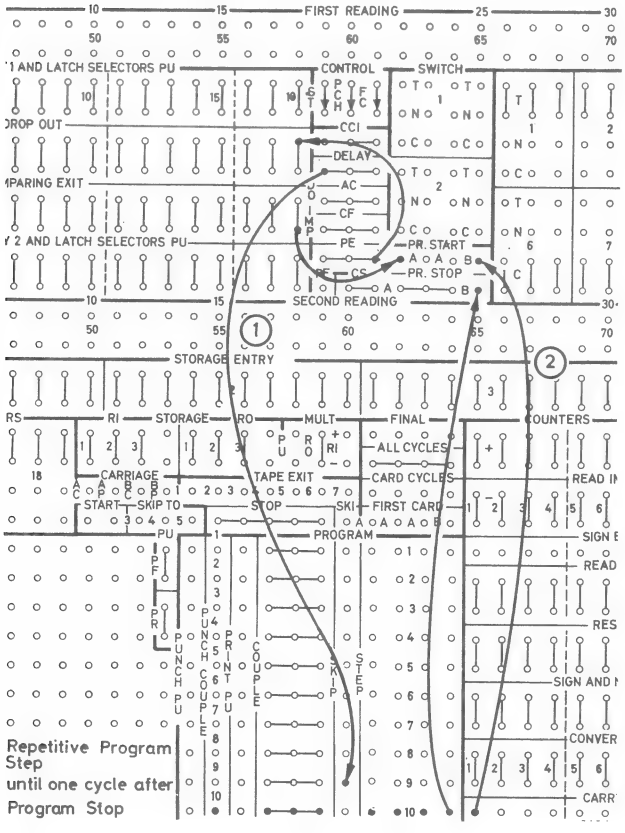


Fig. 16

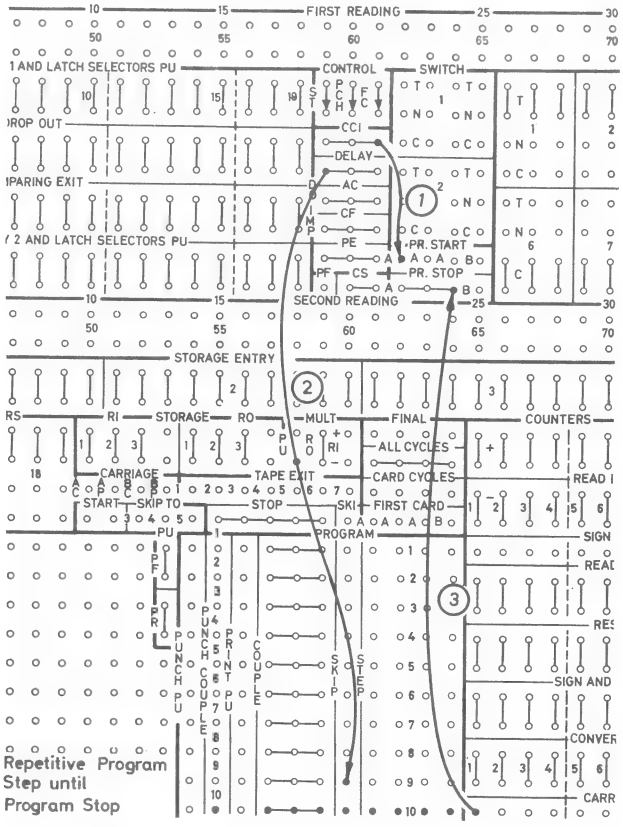


Fig. 17

ple from the Carry Exit hub. If the carry impulse is emitted in a card cycle (if, in this particular wiring, for example, a zero amount is read in) the program is suppressed.

In a complete wiring, counter 1 must be reset at the beginning of the run by means of a Final impulse.

Figure 18 shows the wiring for a repetitive program step with two initial steps. By this wiring two steps can occur before the repetitive step, as may be necessary, for example, in some gang punching applications before punching of cards can begin.

1. On a control break, the program begins with Program Step row 8.

2. In the second program step, the Program Skip 9 hub emits a B-impulse which is, however, not effective since the Program Skip 10 hub (unlike the other Program Skip hubs) is not an entry hub. Hence the third program step repeats until Program Stop is impulsed, because the Program Skip 10 hub continuously emits a B-impulse which suppresses program rows 1 - 9.

3. The program step is repeated until Program Stop is impulsed (for example, from a Carry Exit hub).

4. The latch selectors used for comparing are dropped out after the last program cycle.

Figure 19 shows the possibility of employing program step rows (program relays), which are not used during the program, for holding co-selectors: the Program Couple hubs normally emit (during a program) an impulse from 330 - 310°. If the corresponding Punch Couple hub is picked up during a card cycle with any (short) impulse, the Program Couple hubs emit an impulse from the moment of pick up until the end of the corresponding cycle. (310°). A program will not be started by this and, likewise, the Program Step exits will not emit in the card cycle.

1. A 12 or 11 control punch from Second Reading is wired, through a column split if necessary, to the Punch Couple 10 hub.

2 In card cycles in which a control punch was sensed, the Program Couple hubs emit an impulse beginning at 12 or 11 im-

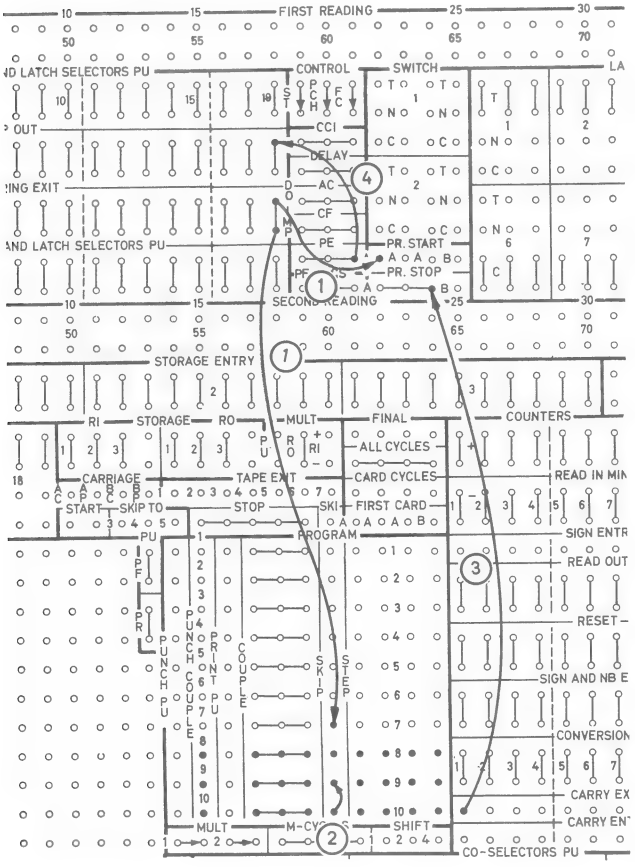


Fig. 18

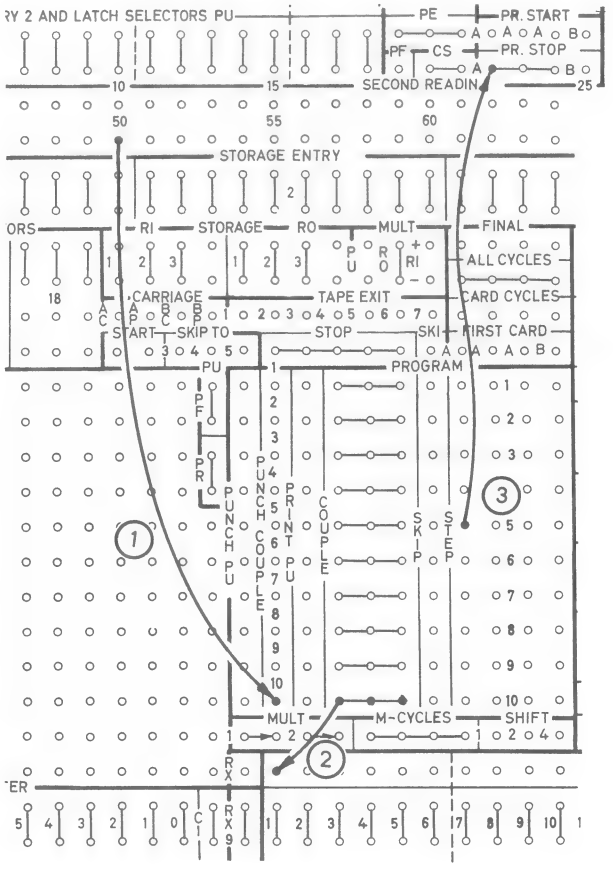


Fig. 19

pulse times respectively, which can be used if desired to hold a co-selector transferred for this cycle. This wiring has the advantage over that previously described for holding co-selectors transferred of not requiring one of the co-selectors' contact positions.

3 The true program uses only 5 steps, so that program row 10 can be used for this purpose without difficulty.

In figure 20 are shown some of the ways of producing additional independent cycle impulses:

1 The All Cycles impulses (7 - 237°) are somewhat shorter than the other cycle impulses (350 - 240°), but are of sufficient duration to control all functions normally controlled with cycle impulses, with the exception of storage read in and read out. Because they are shorter, they can be selected through co-selectors picked up with other cycle impulses. In these examples, All Cycles impulses are wired to the Transferred hubs of co-selectors 1 - 3 and latch selector 15, so that cycle impulses are available from the Common hubs of the corresponding selectors when they are transferred. (Because co-selectors do not have double hubs, split wires must be used).

2 Co-selector 1 is picked up in program step 1 by an impulse from Program Couple 1 (330 - 310°), so that in program step 1 four additional Program Step impulses are available from the Common hubs of co-selector 1, which may be used to control any desired machine functions. Instead of using Program Couple 1 to pick up co-selector 1, one of the four Program Step impulses could have been used, but this would lose one of the Program Step impulses, whilst the Program Couple impulse is always available.

3 Co-selector 2 is picked up with a Card Cycle impulse (350 - 240°) so that in card cycles four additional Card Cycle impulses are available.

4 Co-selector 3 is picked up from First Card B (First Card A could be treated similarly), so that in the first card cycle after a B-program four independent card cycle impulses are available.

5 If co-selectors are not available for expanding cycle impulses, latch selectors can be used. How additional card cycle impulses can be obtained is shown here: latch selector 15 is picked up with a D-impulse from the PE hub, which emits at the beginning of the first card cycle after a program. Thus latch selector 15 is transferred during the following card cycle. It can be dropped out again by a D-impulse, in this case from Punch Couple 1 which emits at the beginning of the first program cycle. Consequently the selector is normal during the program.

Fig. 20

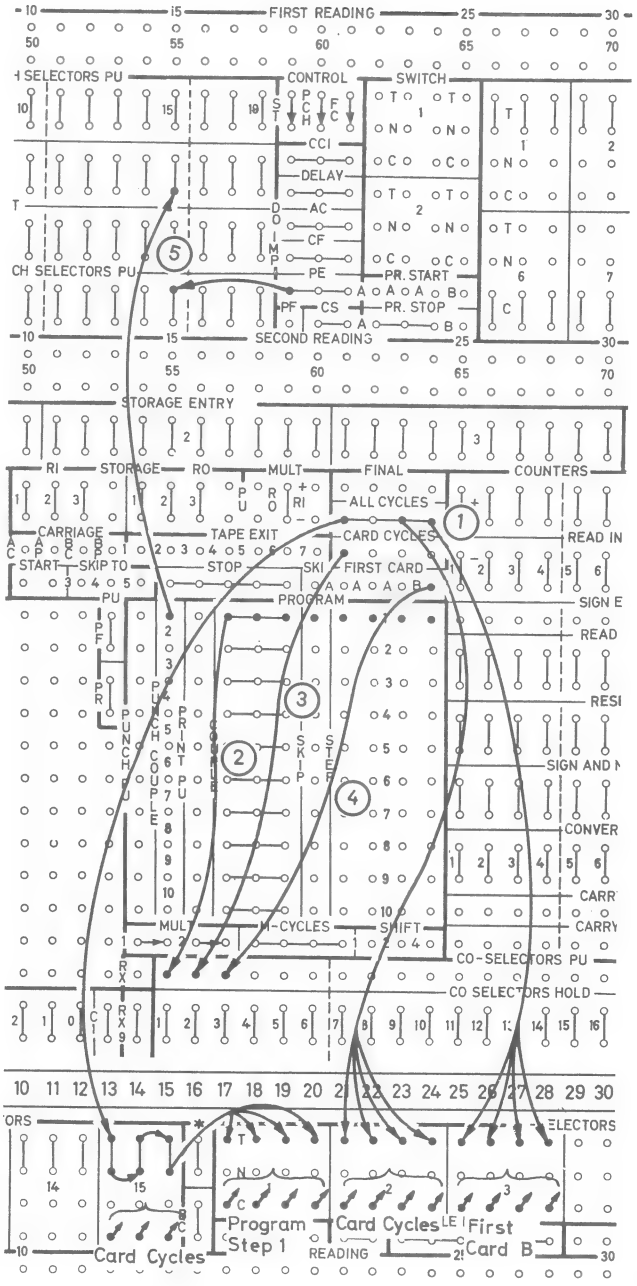


Figure 21 shows how latch selectors, which are used during card cycles for comparing, can be used during programs for other functions:

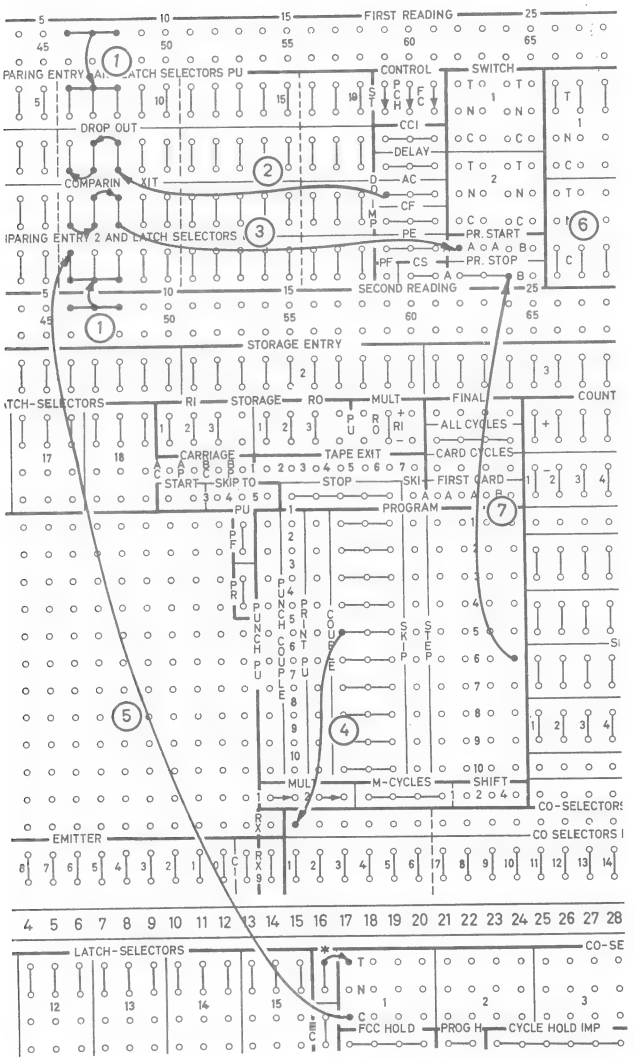
1 Latch selectors 6 - 8 are used in card cycles for comparing.

2 Instead of the usual D-impulses from the PE hubs, those from AC are used, to drop out the latch selectors so that the selectors are normal during the program.

3 Program Start A is picked up with the B-impulse on a control break.

4 Co-selector is transferred during program step 5. It is assumed that the co-selector is used for other purposes and that one position is available for this.

Fig. 21



5 Latch selector 6 is picked up with a 12 impulse from the * hub (Program Cycle Symbol) through the Transferred side of co-selector 1, and remains transferred until 310°, at which time the AC Drop Out hub emits (connection 2).

6 Latch selector 6 is transferred during the fifth program step and can be used to select digit impulses 11 - 0, A, B and C impulses. Because the selector takes a little time to transfer, 12 impulses cannot be selected as the impulse from the Transferred side would be too short, that through the Normal side would not be correctly interrupted and the contact points would be damaged by arcing. The same restriction applies to the selection of cycle impulses: they must only be wired through the Transferred side of the selector. This method was described because it might be useful when selector capacity is limited, although only two selector positions are gained.

7 Program Stop is wired from Program Step 6.

Figure 22 shows the principal wiring for suppression of programs for single card groups. In some applications a program is not required for single card groups. A single card group can be recognized by the machine by the fact that Program Start is again impulsed in the first card cycle after a program.

1 So that the program can be interrupted for a single card group, Program Start A is not picked up with the usual B-impulse from Comparing Exit, but with the earlier A-impulse from CCI wired through the points of latch selectors 1 - 3.

2 In every first card cycle after a program, the First Card A cycle impulse is "provisionally" wired to Program Stop A. If no control break occurs in the first card cycle, this wiring has no effect. If, however, a single card group is present, this impulse will suppress the program.

3 The latch selectors must be dropped out with an AC Drop Out impulse, otherwise they will not be dropped out for a single card group and, in the next card cycle, an erroneous (stored) control break will be indicated.

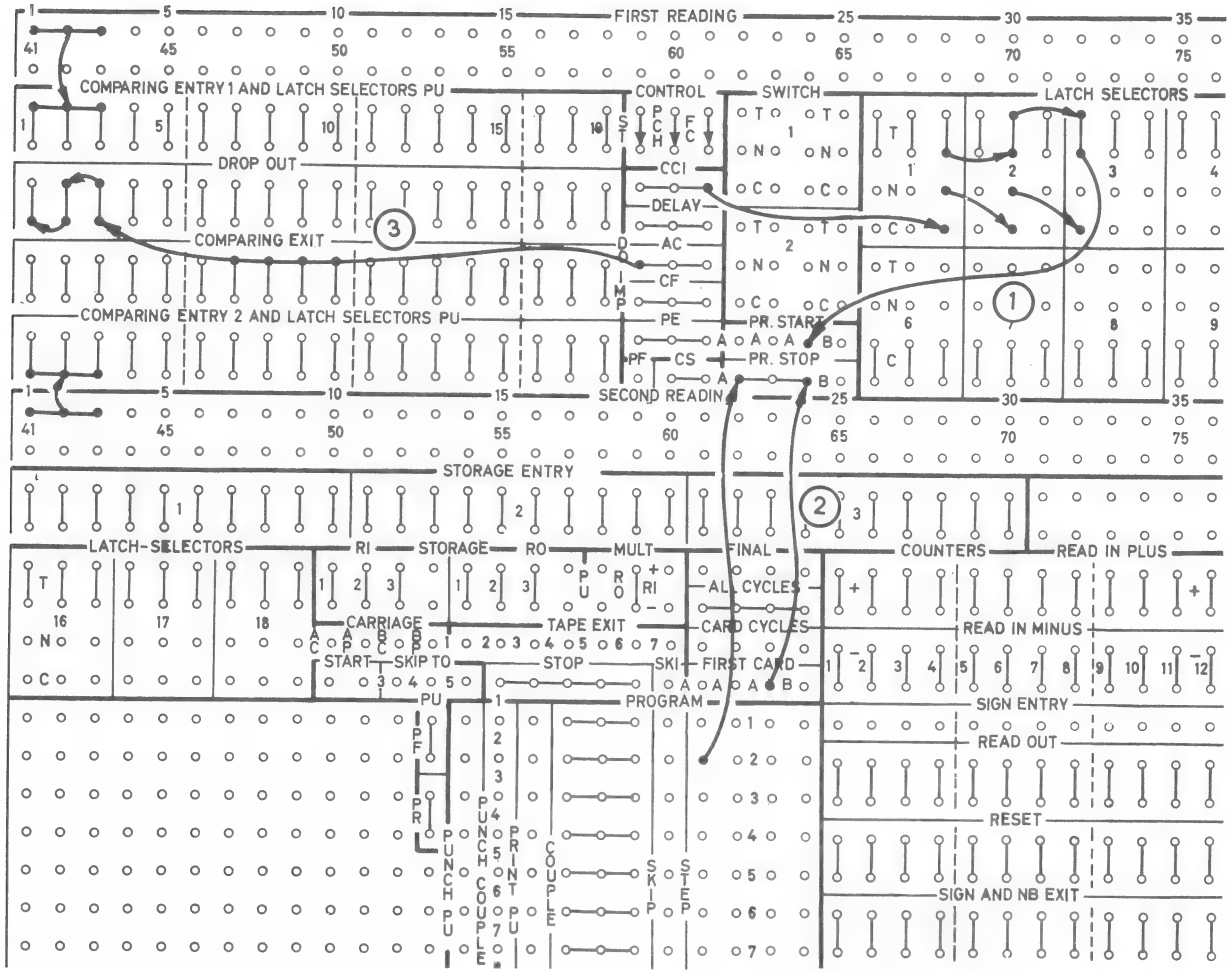

FIRST READING
COMPARING ENTRY 1 AND LATCH SELECTORS PU
CONTROL
SWITCH
LATCH SELECTORS
DROP OUT
CCI
DELAY
COMPARING EXIT
AC
CF
COMPARING ENTRY 2 AND LATCH SELECTORS PU
PE
PR. START
PF
CS
PR. STOP
SECOND READIN
STORAGE ENTRY
LATCH-SELECTORS
RI
STORAGE
RO
MULT
FINAL
COUNTERS
READ IN PLUS
ALL CYCLES
CARRIAGE
TAPE EXIT
CARD CYCLES
READ IN MINUS
START
SKIP TO
STOP
SKI
FIRST CARD
PU
PROGRAM
SIGN ENTRY
READ OUT
RESET
SIGN AND NB EXIT

Fig. 22

Tape - Controlled Carriage

The tape-controlled carriage controls the feeding and spacing of forms during printing. For further details of the forms themselves - dimensions paper quality etc. - see the "Continuous Forms" Chapter on page 15.

The carriage is controlled by a paper tape, the length of which corresponds to the length of one or more forms. Holes are punched in this tape to identify particular printing lines on the form.

Control Tape

The IBM 3000 Accounting Machine uses the same control tape as other IBM Accounting Machines. Of the 12 vertical lines (channels) on the tape, the IBM 3000 uses only channels 1 to 7. The horizontal lines correspond to the lines on the form and are spaced at 1/6 inch intervals. A maximum of 132 lines can be used for the control of a form, although for convenience the tape blanks are somewhat longer. The forms can thus be of up to 22 inches (559 mm) in length.

A row of small, round holes is prepunched in the centre of the tape. These are feed holes to guide the tape accurately through the tape sensing unit. This sensing unit consists of seven reading brushes, which sense the channels of the control tape. Impulses corresponding to holes sensed in the tape may be used to control carriage movement. The control tape passes beneath the sensing brushes in synchronism with the movement of paper through the carriage. The effect is thus the same as if the control holes were punched in the form itself.

Control Tape Channels

A control tape need not be used if, for example, a simple listing with single or double line spacing is to be made on a roll of paper.

It should be noted that in this case the sensing brushes must be lowered onto the contact drum.

In all other cases, particularly if forms are to be printed, a hole must be punched, in an allotted column, for every printing line on that form.

Channel punchings are used to stop form movement at a particular line. A Tape Exit hub is provided on the control panel for each of the seven channels. These hubs do not emit when the carriage is stationary. However, as soon as a skip is initiated, these hubs emit impulses whenever the corresponding brushes touch the contact drum, that is whenever a hole is present in the tape. These impulses are timed to occur whilst the platen is moving between two print lines.

If there is no tape in position and the sensing brushes are resting on the contact drum, all seven of these hubs emit short impulses, at a rate of 24 per cycle (see Timing Chart) whilst the carriage is moving. Channel 5 is an exception to this, however (see below).

In many applications, one can regard the seven channels as being identical. In certain cases, however, the differences between them may be used to advantage.

Channel 7 should be punched for the first line of a form. This is the initial or "home" position of the tape.

Channel 3, 4 and 5 should be used for controlling skipping by the Skip To 3, 4, 5 hubs. In this case Carriage Stop need not be wired.

Channel 5 has a special characteristic: whereas the other channels are always operative, with the appropriate Tape Exit hub emitting an impulse when a punched hole is sensed, channel 5 does not emit when a hole is sensed during the course of a skip to 3 or 4. By this means, an overflow program can be initiated on the last line of a form This can be made to govern various machine functions, such as printing balances carried forward and so on, before skipping to the next form.

Channels 1, 2 and 6 are identical and are wired directly, with no internal function, to the control panel. As a precautionary measure, Tape Exit 6 may be wired to SKI (Skip Interlock), if such a connection is necessary.

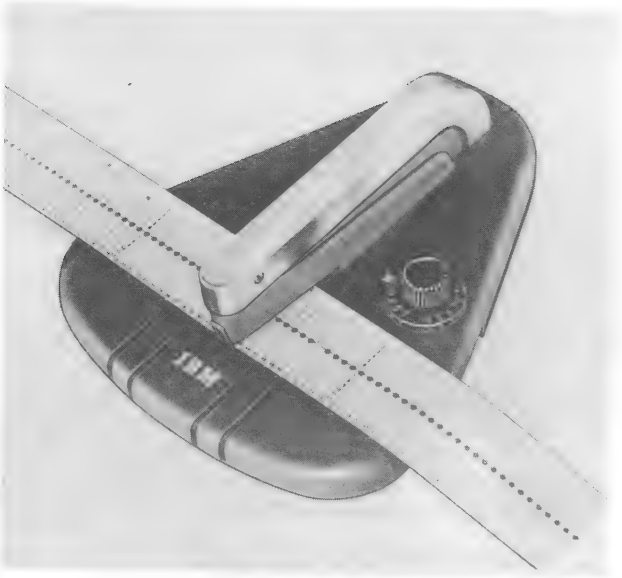


Fig. 1 Tape Punch

A small compact punch (Figure 1) is provided for punching the tape.

The tape is first marked in the channels in which holes are to be punched. For this the tape may be laid beside the left hand edge of the form, with the top line (immediately under the glue portion) level with the top edge of the form.

The marking for one form should be repeated as many times as the usable length of the form will allow (132 lines). With the tape thus serving to control several forms in one revolution through the sensing mechanism, the life of the tape is increased. Finally, the line corresonding to the bottom edge of the last form should be marked for cutting after the tape is punched.

The tape is inserted in the punch with the line to be punched aligned with the guide line of the punch and the centre feed holes fitting over the two pins projecting from the base. The dial is turned to select the appropriate channel, which is punched by pressing the top rear end of the punch arm.

After the tape is punched, it is cut and looped into a belt. The bottom line is glued to the top line, so that the first and last lines are adjacent. The centre feed holes must coincide when the two ends are glued together.

The last hole punched in the tape should not be less than four lines from the cut edge, as the last three lines of the tape overlap the glue section when the two ends are spliced. If it is necessary to punch a hole less than four lines from the end of the form, the tape should be placed four lines lower before marking the channels and should be cut off four lines lower than the end of the form If this also is not possible, the hole in the glue section should be punched after gluing the ends together; care should be taken to avoid having the tape too short for this - a little forethought can guard against this.

Inserting the Tape

The cover of the print unit may be raised to gain access to the tape sensing mechanism. The tape can then easily be inserted at the left side of the machine. For this, the brushholder is raised until it latches, so that the pin-feed drum is exposed. With the tape held so that the printed captions can be read from the left side of the machine, one end of the loop is placed over the pin-feed drum so that the pins engage in the centre feed holes. The brushholder can be lowered again by pressing it slightly

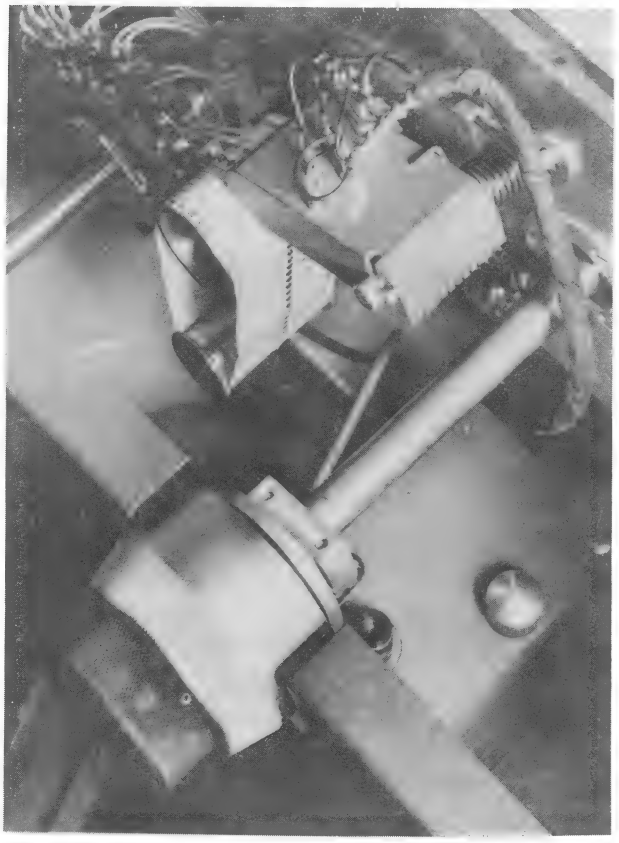


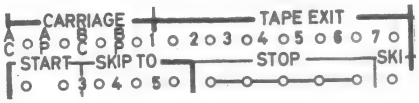
Fig. 2 Tape Reading Mechanism
Platen Knob and Vernier

towards the print unit, to disengage the latch. To avoid damage to the freely hanging tape loop during machine operation, the metal spool provided should be placed in the lower end of the loop to keep the tape taut.

Carriage Control

Every skip or space is controlled by control panel wiring. The hubs relating to the carriage are grouped in approximately the centre of the upper half of the control panel.

Q-R/10 - 20



A carriage movement will be ended when a punch is sensed in the appropriate channel of the control tape, as determined by control panel wiring.

By suitable selection of channels and arrangement of punches in the tape, forms of practically any desired format can be handled.

The control panel wiring examples devoted to this chapter show only the wiring concerned directly with the carriage control. These examples serve only to clarify the principle uses and do not show the complete wiring possibilities for any individual case.

Most carriage wiring falls into two types:

1) By external wiring alone: initiating skips by the Start hubs and selecting the desired channels (Method A).

2) By external and internal wiring: initiating skips by the Skip to 3, 4, 5 hubs and automatically selecting the associated channels (Method B)

Both methods have their advantages; in individual cases only one or other type can be chosen, in complex wirings the two methods may be combined.

Skipping by Method A

CARRIAGE START R/10-11

A short impulse (12-0, A or C) to either of these hubs sets the carriage in motion immediately. During skips the platen is coupled to the main drive of the machine and moves at a rate of 24 lines per machine cycle. The carriage movement is stopped by an impulse to one of the Carriage Stop hubs. Normally, the Carriage Start hubs are impulsed only with 12 and C impulses from the four Carriage hubs immediately above them. However, in theory, any other short impulses - for example, from the card in question - could be used if single, double or triple spacing is required selectively. When skipping is wired by method B (see below), the Carriage Start hubs are inoperative.

AC (After Hammer Trip - Card Cycles) Q/10
AP (After Hammer Trip - Program Cycles) Q/11

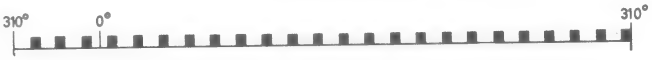
BC (Before Hammer Trip - Card Cycles) Q/12
BP (Before Hammer Trip - Program Cycles) Q/13

These hubs emit C or 12 impulses in all card or program cycles accordingly in which the print unit operates. The impulses may be wired to one of the Carriage Start hubs to initiate carriage movement.

The C impulse occurs immediately after hammer-trip (252-257°) so that, for printing in the next cycle, up to 22 lines can be skipped without loss of time.

The 12 impulse is considerably further away from hammer-trip time than the C impulse; it occurs before hammer-trip in the same cycle. In this case only 14 lines can be skipped without loss of time.

TAPE EXIT 1 - 7 Q/13-20



These seven hubs are the exits for the seven channels of the paper tape. Each of these hubs emits an impulse if a hole is sensed in the corresponding channel whilst the carriage is in motion. Tape Exit 5 is an exception to this, as it does not emit during skips to 3 or 4 initiated be method B. Tape Exit impulses are usually wired to Carriage Stop to terminate skips caused through Carriage Start (Method A). This wiring is not necessary for skips controlled by method B.

Channel 7 is used to recognise the "home" or "restore" position of the form, by which the tape can be adjusted to correspond with the first line of the form.

Apart from these special characteristics of channels 5 and 7, all seven channels are equivalent. As well as the normal wiring to Carriage Stop, Tape Exits 1 - 7 can also be wired to control other machine functions, for example: Program Start, selector pick-up and so on. It should be noted that the timings of these impulses are not so de-

finitely fixed as those of the other impulses and depend primarily on the length of the skip.

CARRIAGE STOP R/15-19

In method A skipping, carriage movement is terminated by impulsing Carriage Stop with a Tape Exit impulse. No other impulse may be used for this purpose. This connection may be wired directly or through selectors.

In method B skipping, this connection is not necessary, because selection of the required channel (3, 4 or 5) is made internally. At the same time, the Carriage Stop hubs are inoperative, so that connections from other Tape Exits to these hubs need not be selected out when a combination of both methods is employed.

Wiring Examples for Method A

No. 1 Single Spacing and End-of-Form Skip

The form is 6 inches (15,2 cm) long, on which 25 lines are to be printed (during card cycles only). When the last line of the form has been reached, a skip to the first line of a new form follows. In this example 12 lines are skipped.

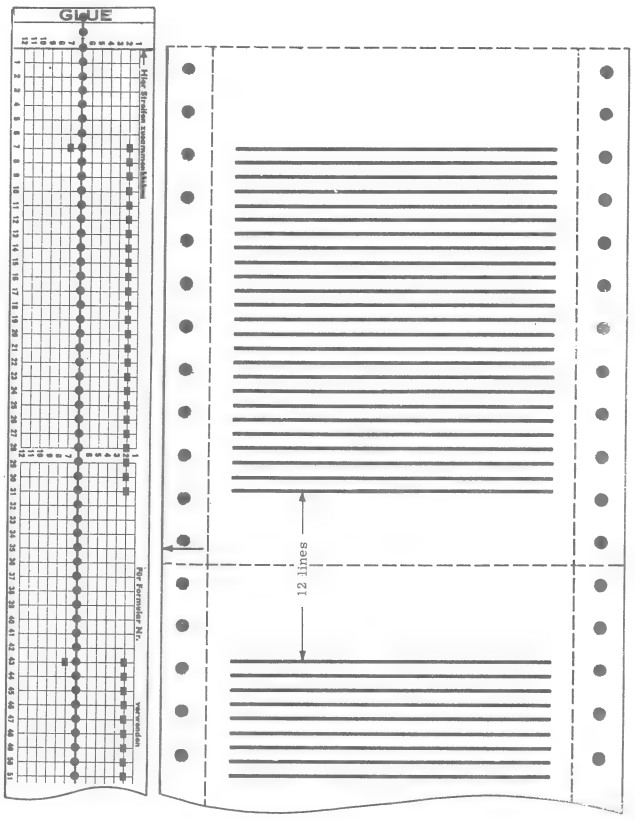
Control Tape

The control tape is punched with 25 holes in channel 2, lines 7 - 31. In principle, any one of channels 1 to 6 could have been chosen, with the appropriate tape exit wired to Carriage Stop. Channel 7 contains the control punch for restoring the form to the first printing line.

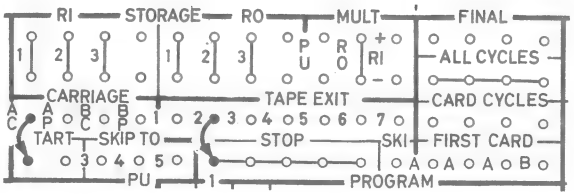
As the form is 6 inches long (36 lines), it is recommended that the punching for a form be repeated three times on the tape.

Control Panel Connections

Because printing only takes place during card cycles in this example, only two wires are necessary: from Carriage AC to Carriage Start and from Tape Exit 2 to Carriage Stop.



No. 1

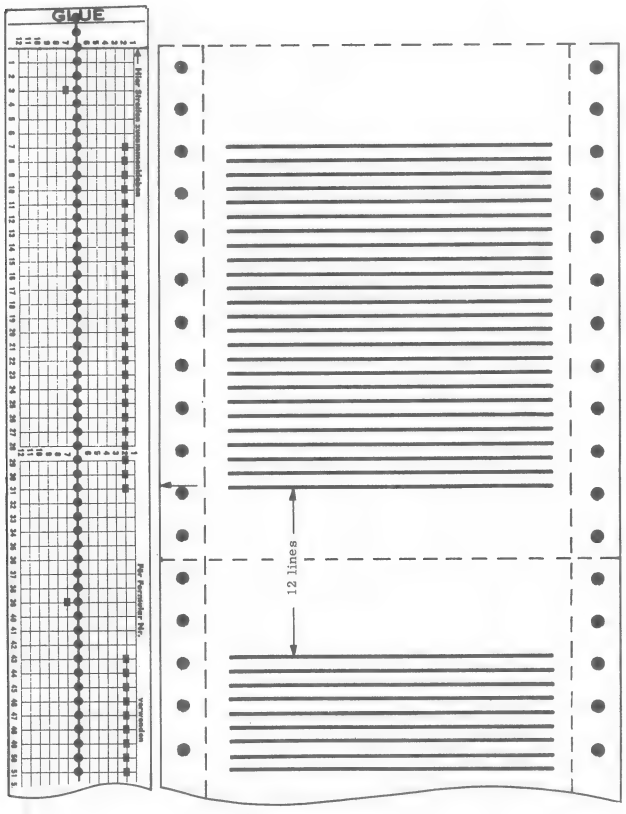


No. 1

Note: The continuous stationery should always be made with a preprinted set-up mark, consisting of a thin line or arrow, 8 lines (1 1/3 inches - 34 mm) above the first printing line of the form. When inserting the forms at the beginning of a run, this mark should be aligned with the tear-bar of the print unit.

No. 2 Single Spacing and End-of-Form Skip

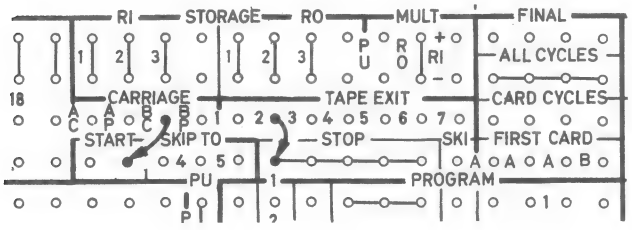
(As in Wiring No. 1 but with space before hammer-trip)
The same print format as in figure 1 will be achieved if spaces (and skips) are started before hammer-trip.



No. 2

Control Panel Connections

The only difference between this wiring and the preceding is that Carriage BC, instead of AC, is wired to Start.



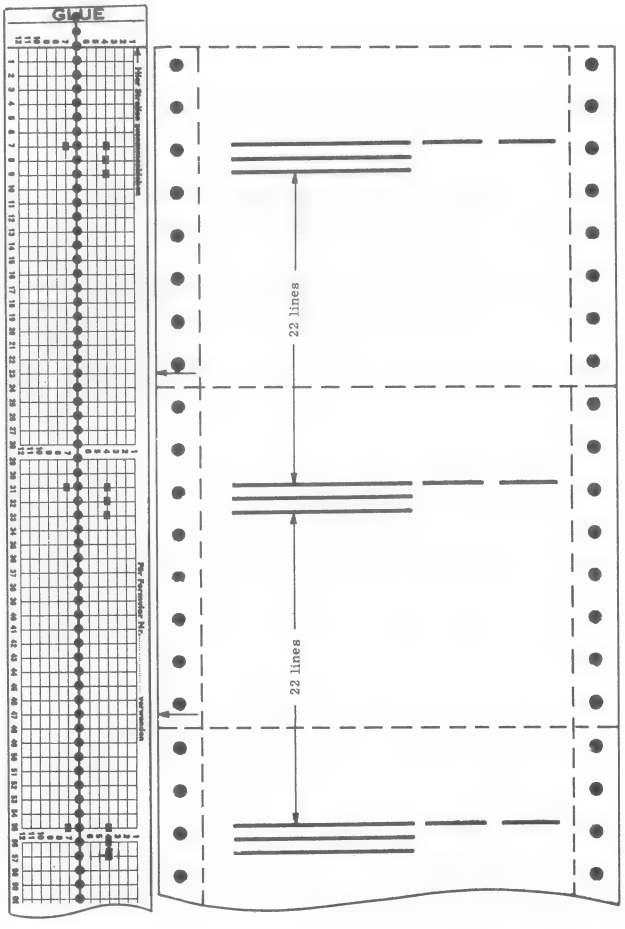
No. 2

This method of wiring is quite permissable, but should only be used in special circumstances, as it has a disadvantage:

The restore position hole in channel 7 cannot be punched level with the first line of the form because the first printing is preceded by a skip. In this example, four lines are skipped before the first printing line. It should be noted that the set-up mark should be printed 8 lines above the hole in channel 7 and not 8 lines above the first printing line. This means that the hole in channel 7 must always be punched a definite distance ahead of the first printing line if the first skip is released by a before hammer-trip impulse. It is therefore impossible to have the set-up mark in the same place for forms which may be used on occasions with skips or spacing before hammer-trip and on other occasions with skips or spacing after hammer-trip.

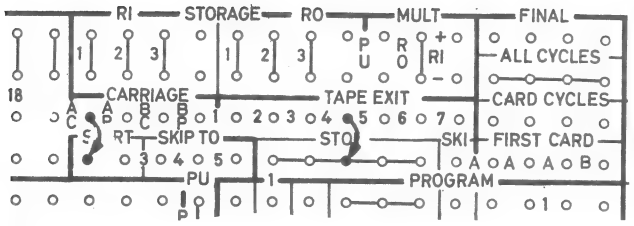
No. 3 Share Statements

In this example share statements, 4 inches (10, 2 cm) in length, are to be printed. There are three cards for each statement.



No. 3

There is an interval of 22 lines between the last printing line of one form and the first printing line of the next. This can be skipped over without loss of time, thereby giving a listing speed of 1800 documents per hour.



No. 3

The wiring is similar to that for example no. 1. Consequently, group control is not wired and so printing will get out of step if a card is missing from a group. On the other hand, method B allows only 18 lines to be skipped over without loss of time. In practice, the forms would have been made shorter and method B used for safety.

No. 4 Printing Two-part Forms

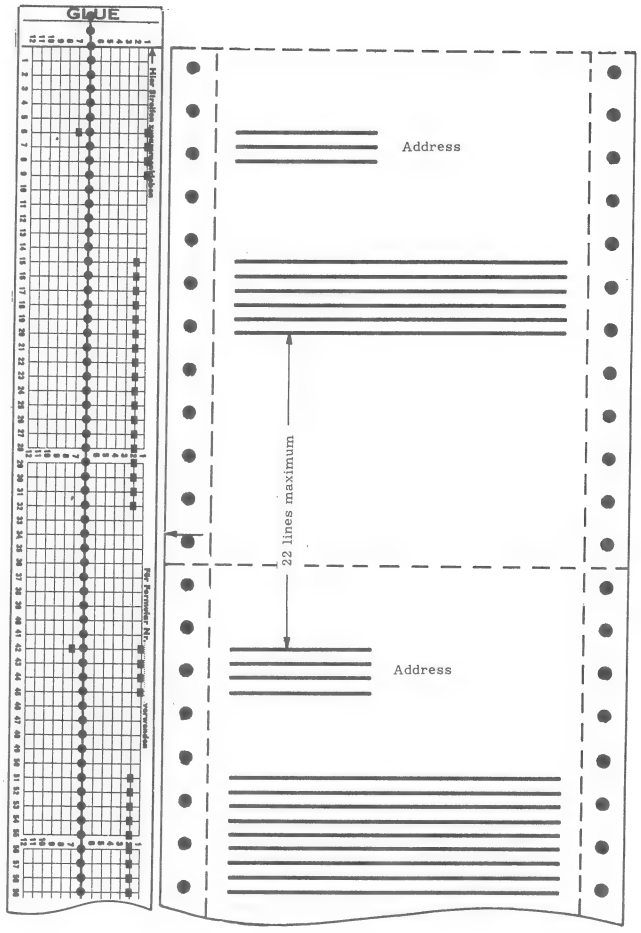
In this example the form is 6 inches (15, 2 cm) long. It consists of a heading portion and the main body of the form. For the sake of simplicity, it is assumed that printing takes place only in card cycles. There are two classes of card:

Address Cards have X in Card Col. 5
Detail Cards have X in Card Col. 10

Always, if the number of print lines in any section of the form (heading, body, etc) is variable, the control tape channels must be selected.

In this example it is assumed that there are always 2, 3 or 4 address cards and at least 6 detail cards present. If there are fewer than 6 detail cards, the distance to the first heading line of the next form is greater than 22 lines, so that the first heading line will be printed during the skip.

Up to 18 detail cards can be printed on one form. If there are more cards, the 19th detail card will be printed on the next form and the heading portion skipped over. The skip to this line is of only 19 lines so that in this simple manner the overflow problem is solved. A continuation form is easily distinguishable from a form with a missing address.

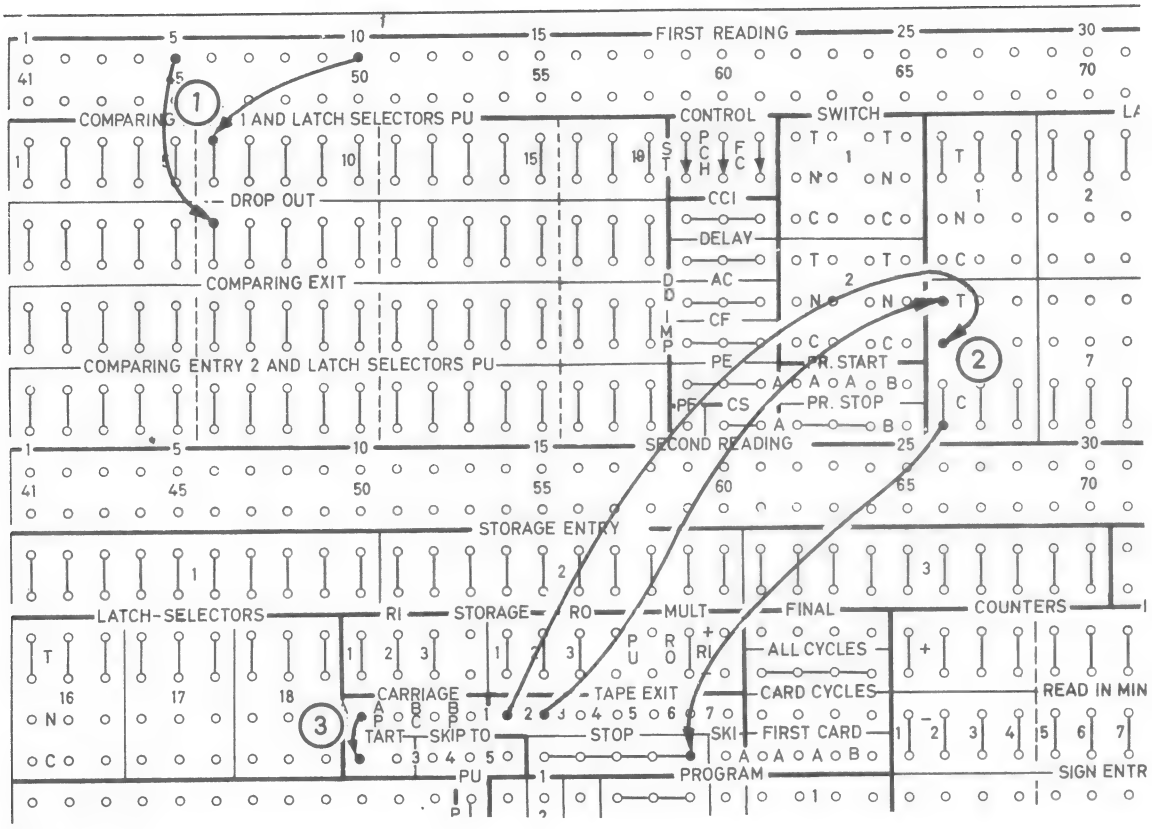


No. 4

Control Tape

As the form is 6 inches (36 lines) in length, it is recommended that the holes for three complete forms are punched consecutively on the one tape.

For each form, channel 1 contains four holes for the heading and channel 2 has 18 holes for the detail lines. Channel 7 is punched on a level with the first heading line.



No. 4

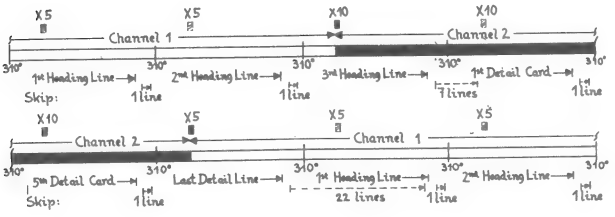
Control Panel Wiring

1. The X in column 5 of heading cards is wired to drop out latch selector 6, which is picked up by the X in column 10 of detail cards. These two columns are assumed to contain no punches other than these X punchings, otherwise these connections must be made via a column-split coselector.

2. Latch selector 6 selects the channel used to stop skips.

3. Carriage Start is wired from Carriage AC.

The following sequence diagram shows the timings of various machine functions in the first four print cycles and on a change of form.



The double lines show the status of latch selector 6; the broken lines indicate the length of each skip.

Selectors are picked up and dropped out from First Reading. Since only the first of a number of impulses to the pick up or the drop out of a selector has any effect, these other impulses are shown hatched.

In this example the selector is picked up, whilst the third address line is being printed, by the X column 10 of the following first detail card. This means that a skip initiated in the preceding cycle must be completed by this time. Otherwise, the wrong tape channel will be selected or the selector will be damaged if a tape impulse is sensed immediately it transfers. The first error condition arises if a single address card follows the last detail card: then, in the penultimate cycle of the above sequence diagram, the selector will again be picked up by the X in column 10 of the first detail card following the address card, whilst the skip is taking place, and the address line will print incorrectly in the body of the form.

The second error condition occurs when a single detail card follows the address (which is already out of the question on other grounds). In the fourth cycle of the sequence diagram, during the printing of the first detail card, the selector will be transferred by an X in column 5 of the following first address card at the precise moment that it would be selecting an impulse, if the skip was seven lines in length.

This gives the following rules for skipping by method A:

1. Skips by method A may be up to 22 lines long, if the channel is not selected during the skip.

2. If the number of print lines on a form is variable, a different channel must be chosen for the next part of the form.

3. The channel may not be selected during the course of a skip.

The last error condition, which must always be guarded against, occurs when only the first line of a part of a form is to be printed. This line is reached by a longer skip and consequently the channel will be changed.

These difficulties can be overcome if the particular latch selectors are picked up and dropped out by B impulses. This, however, requires additional selectors.

No. 5 Printing on forms with predetermined total lines

This example differs essentially from the preceding in that a total line is to be printed, during a program cycle, on each form. This wiring gives correct results even if only one line each is printed in the heading and the body of the form, as can be seen from the sequence diagram. The same applies to the overflow condition.

Control Tape

In addition to the four holes for the address, channel 1 is also punched for the total line in line 35. The same channel is chosen here for the sake of simplicity: a heading line always follows a total line.

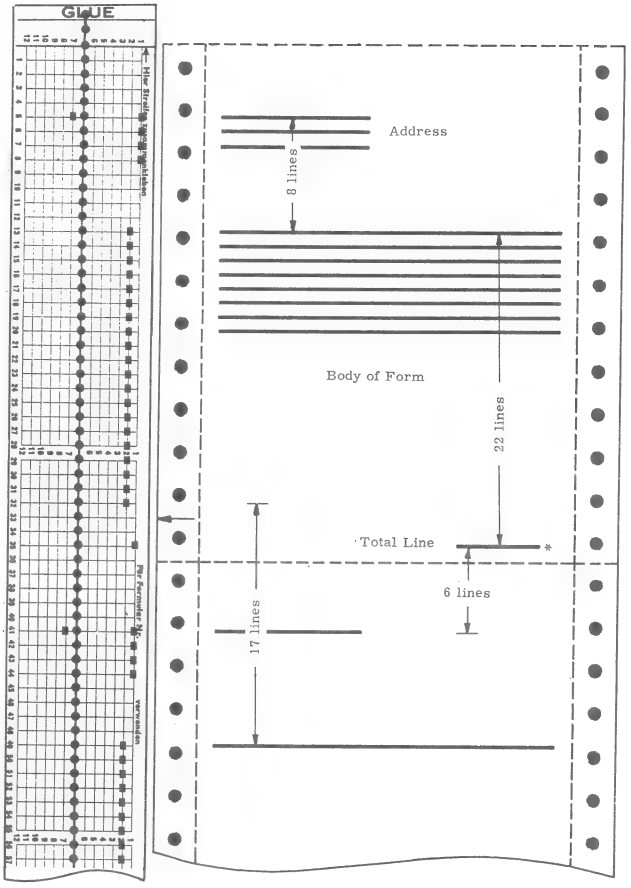
Channel 2 contains 20 holes for each form, for the detail lines. The interval between the last line of one form and the first body line of the following form is 17 lines, so that the 21st detail card can be printed on the following form without loss of time.

Again, channel 7 contains the hole for the home position

Control Panel Connections

1. Columns 1 - 4 are wired for group control, into Comparing Entries 1 - 4.

2. Comparing Exit is wired via the common Drop Out hubs of latch selector 6 to Program Start A.



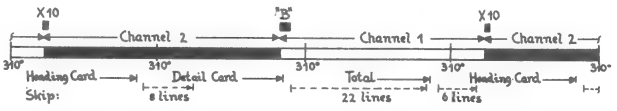
No. 5

3. The X in column 10 of detail cards is wired from First Reading to pick up latch selector 6.

4. Channels are selected in the same manner as in previous examples.

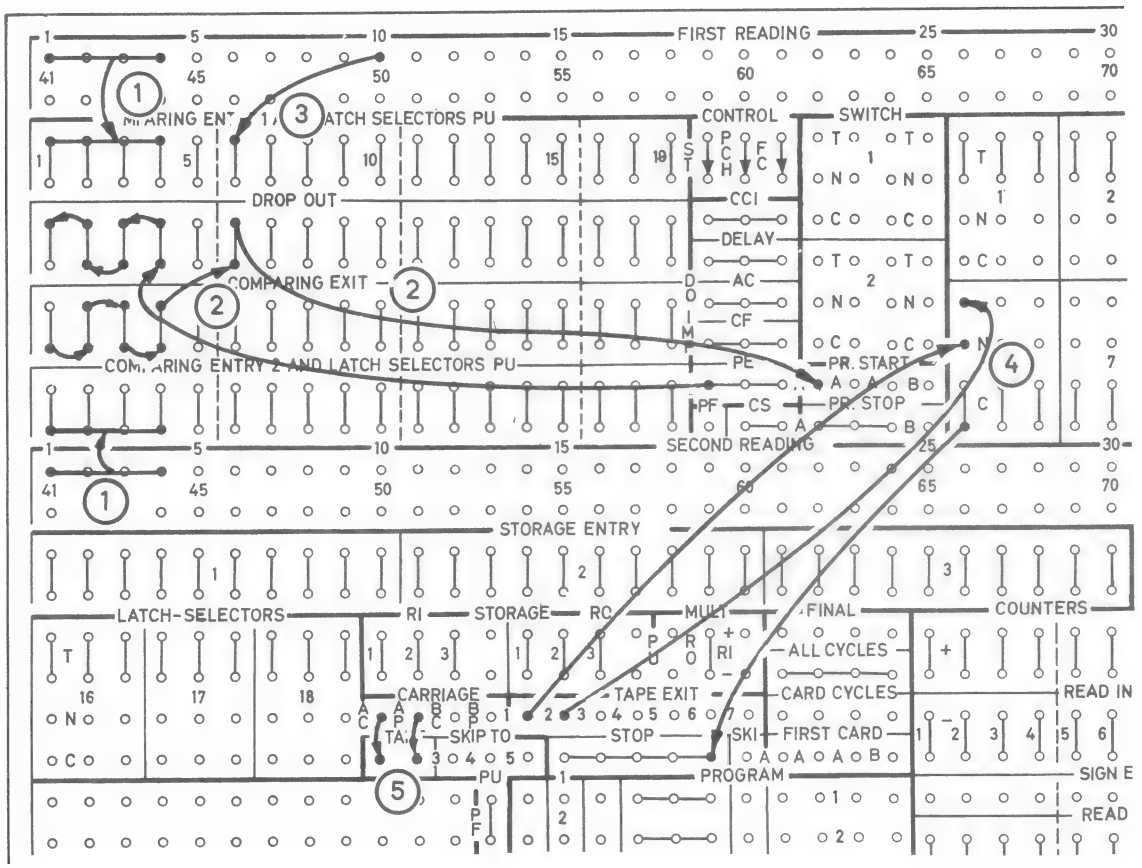
5. Since printing is required in program cycles, Carriage AP is wired to Carriage Start.

The following diagram shows the sequence of operations in the event of there being only one heading card and one detail card for each form.



This sequence diagram shows four consecutive cycles. Latch selector 6 is picked up by an X in card column 10 when the first detail card is at first reading (cycles 1 and 4) and is dropped out by the Comparing Exit "B" impulse when the last detail card is printed.

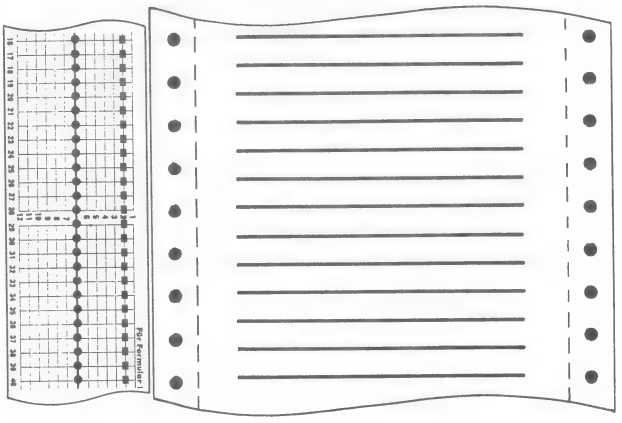
The skip at the end of cycle 1 is, in this case, of 8 lines. It could be longer, because the selector is transferred until B impulse time.



No. 5

The skip at the end of cycle 2 is of 22 lines. Here, also, the selector is unchanged during the skip. Only the skip at the end of the third cycle is critical: it is limited here to 6 lines by the design of the form, because the selector can be switched by an X impulse in the event of a single heading card. If, as was established at the outset, there are always at least two heading cards, a longer skip is also possible here and the form can be arranged differently.

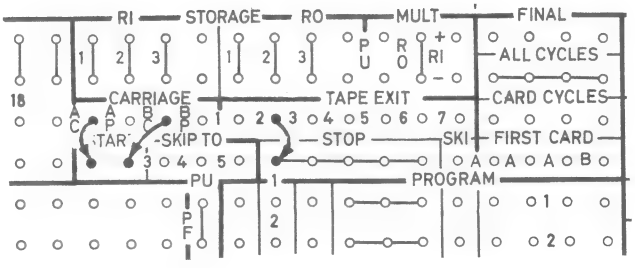
The following examples are concerned with spacing and deal with only a part of a form, for example the body part. Since, in these examples, every line of the tape is punched, the effect is the same as though no tape were in position.



No. 6

No. 6 Double Spacing

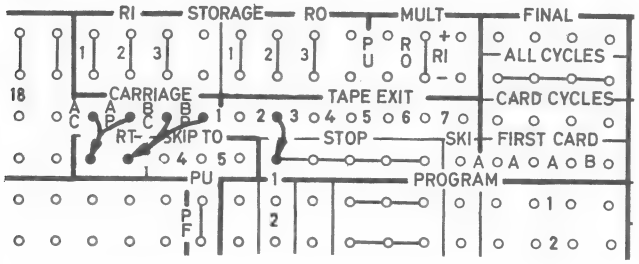
Double spacing can be achieved by causing two separate space operations between two print cycles. This is also valid when no control tape is in position. If a large amount of double spacing is required, it may be worthwhile using a control tape with holes only in every second line.



No. 6A

If only card cycles occur, spacing can be wired as follows:

If both card and program cycles occur, both pairs of Carriage hubs must be splitwired into Carriage Start.

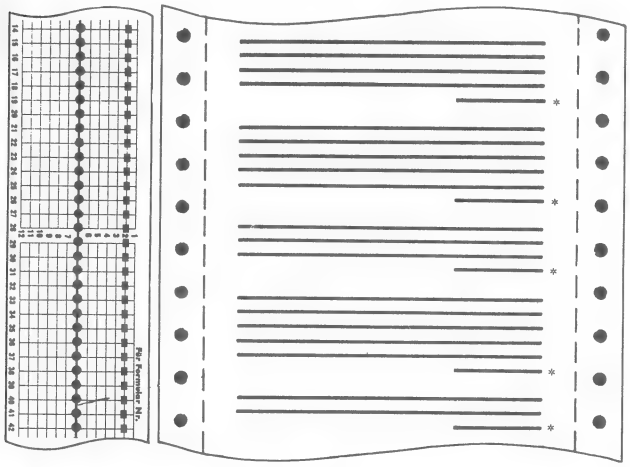


No. 6B

It should be noted here that only hubs of the same type may be splitwired together, thus: AC and AP hubs (C impulse) or BC and BP hubs (12 impulse).

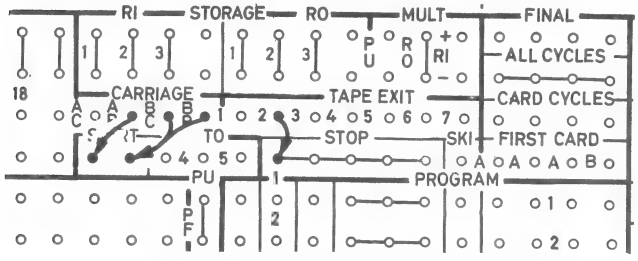
No. 7 Additional Space for Group Change

It is here assumed that, after a number of card cycles, a program intervenes, in which a group total is to be printed.



No. 7

A space is required between the individual groups. This can be obtained by causing the normal single space by means of a 12 impulse from the BC and BP hubs and the additional space after the program cycle by means of the impulse from the AP hub.

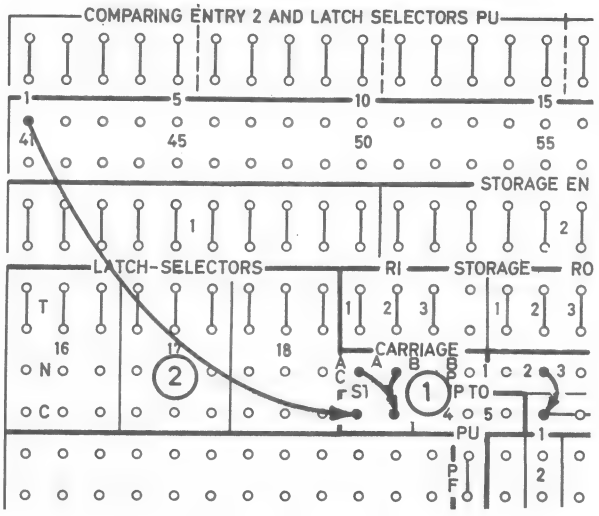


No. 7

When printing is required on more than one program cycle, the impulse from the AP hub must be selected and only allowed to take effect in the last program cycle.

No. 8 Additional Spacing by X Punches

The same print format as in example 7 can be obtained if the first card of a group contains an X punch in one of its columns.



No. 8

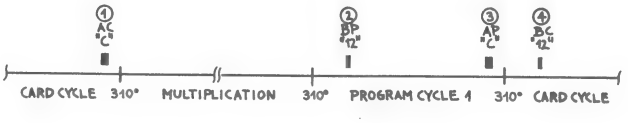
Control Panel Connections

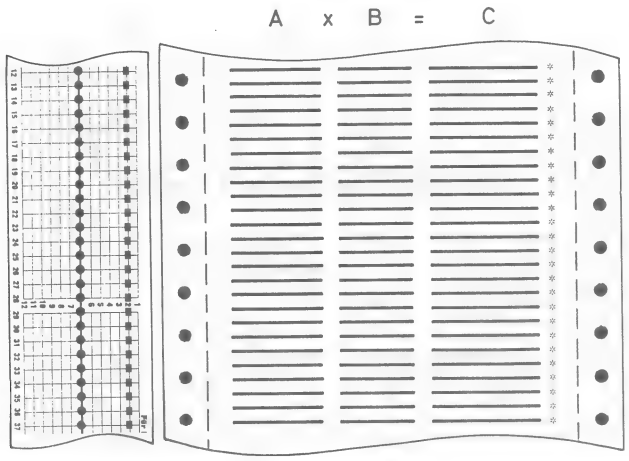
1. In this case the normal spacing, from the AC and AP hubs, can be wired.

2. The X identifying punch in the first card of a group is wired directly to Carriage Start. If this column also contains numerical punches, the connections must be made through a column split.

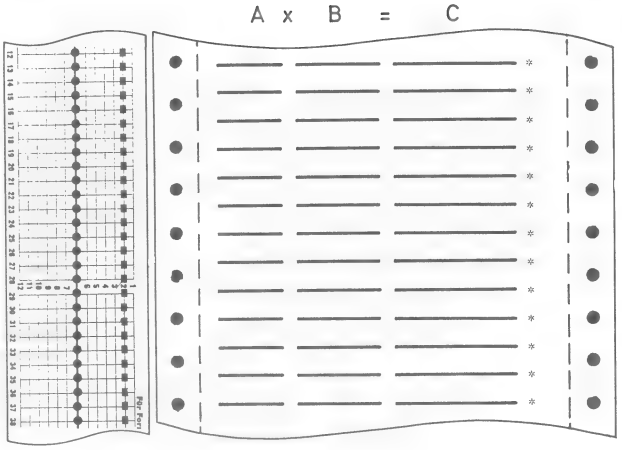
No. 9 Single Spacing for Multiplication

In a multiplication A x B = C, the product should print on the same line as the factors. It is here assumed that a multiplication ensues after every card and that the results are printed during a program. The following diagram shows the cycle sequence and the timing of carriage impulses:



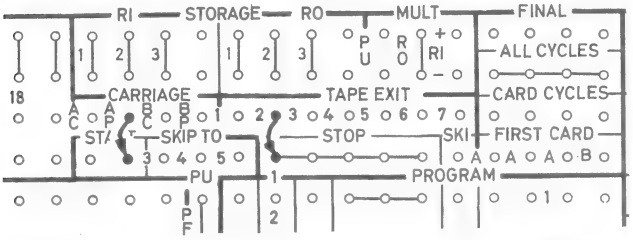


No. 9

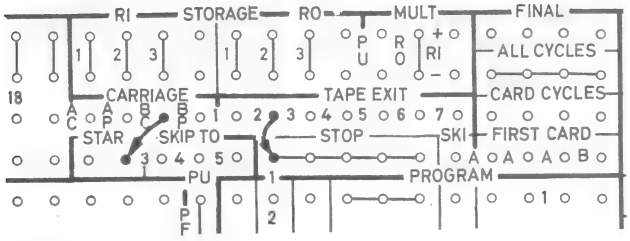


No. 10

In such a "loop" (card cycle, Multiplication, Program cycle 1) each of the four Carriage impulses is emitted once. In order to obtain the desired format, the two carriage impulses occurring between the card cycle and the program cycle (AC and BP) are not required. The necessary space can then be caused by either the AP or the BC impulse:



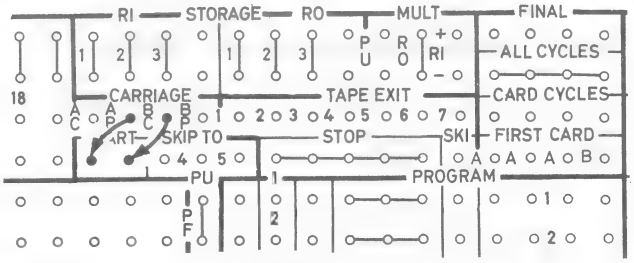
No. 9A



No. 9B

No. 10 Double Spacing for Multiplication

In this example, likewise, the product is to be printed on the same line as the factors.



No. 10

From the sequence diagram, it follows that two carriage impulses (AP and BC) are available between printing the product, in the program, and printing the next factors, in the following card cycle.

Skipping by Method B

SKIP TO 3, 4, 5 R/12 - 14

These three hubs accept A, B and Cycle impulses, in all card and program cycles in which there is a card at the second reading station (even if the cycle is not a print cycle), to cause a skip by method B which is ended by internal control.

Consequently, no control panel wiring from Tape Exit to Carriage Stop necessary.

When two of these hubs are impulsed simultaneously, the hub with the higher number takes priority.

This internal control is effective from A or B impulse time (depending on the pick-up impulse) until 0 impulse time in the following working cycle. During this "skip time" the following functions are automatically controlled:

1. The skip is initiated by means of an internal C impulse.

2. The chosen channel is internally connected to the carriage Stop magnet. Here, the channel with the highest number takes priority, should two of the hubs be impulsed at the same time.

3. The Carriage Stop hub is inoperative; it is therefore unnecessary to select out any connections between Tape Exits and Carriage Stop.

4. During a skip to 3 or 4, Tape Exit 5 does not emit, even if a punch is sensed in channel 5. By this means, an overflow program can be suppressed if the last detail line is skipped over by a skip to 3 or 4, whilst this program will be called if the last line is reached by spacing (by method A).

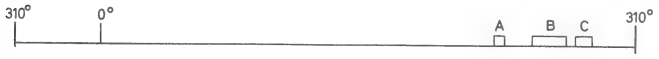
5. During this time, the Carriage Start hubs are inoperative. They therefore do not accept C impulses (AC and AP) in the same cycle or 12 impulses (BC and BP) in the following cycle.

6. The SKI hub (Skip Interlock - see below) can be impulsed to provide the idle cycles necessary for skips of more than 18 lines in length. This hub is inoperative for skips by method A.

In method A skipping, up to 22 lines can be skipped without loss of time; longer skips are not possible, unless a card or program cycle without printing intervenes.

In method B skipping, however, only 18 lines can be skipped without loss of time, because the internal carriage control continues only to 0 impulse time. If the skip is not completed by this time, it will remain picked up in the following cycle, so that a 20 line skip, for example, will cause a second skip to the next hole in the same channel, although this was not wired to take place. Therefore, when using method B, SKI must be wired for all skips longer than 18 lines.

SKI (Skip Interlock) R/20



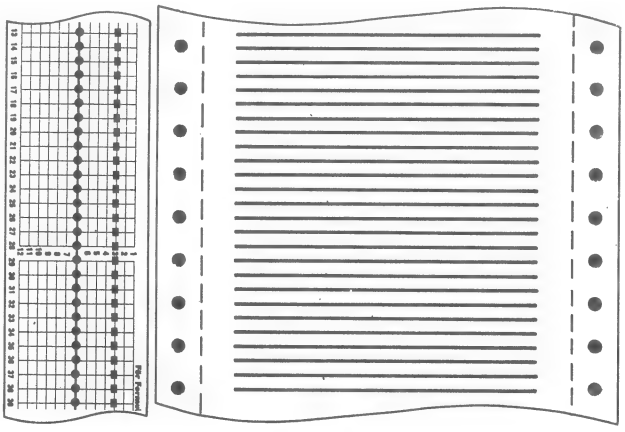
This hub accepts only if one of the Skip To 3, 4, 5 hubs is picked up. Theoretically, it can be impulsed with a selected A, B or C impulse (if, for example, channel 6 is needed for other purposes), but normally it is controlled from Tape Exit 6. Channel 6 must be punched in the first line to be skipped over in the particular skip needing the interlock. If the SKI hub is impulsed at a later time at the beginning of the next cycle, perhaps because of an wrongly designed control tape, this can result in incorrect machine operation and, in unfortunate cases, may even damage the machine. Care should therefore be taken to wire the SKI hub only in the manner described above (see example 13).

If the hub is impulsed and the particular skip exceeds 2 lines, the machine takes idle cycles until the skip is completed. During such idle cycles, only those machine functions indicated by an X in the I column (Idle cycles) of the timing chart are operative; that is, all processing of data is suppressed. The machine automatically resumes operations when the skip is completed.

Wiring Examples for Method B

No. 11 Single Spacing in Card Cycles

This example, like the preceding examples 6 to 10, describes only a part of the form, in which simple spacing occurs in card cycles.



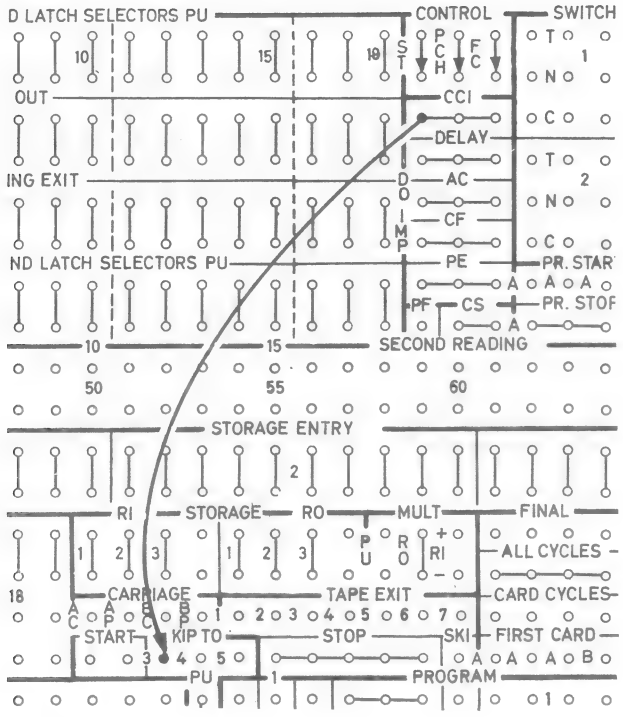
No. 11

Control Panel Connections

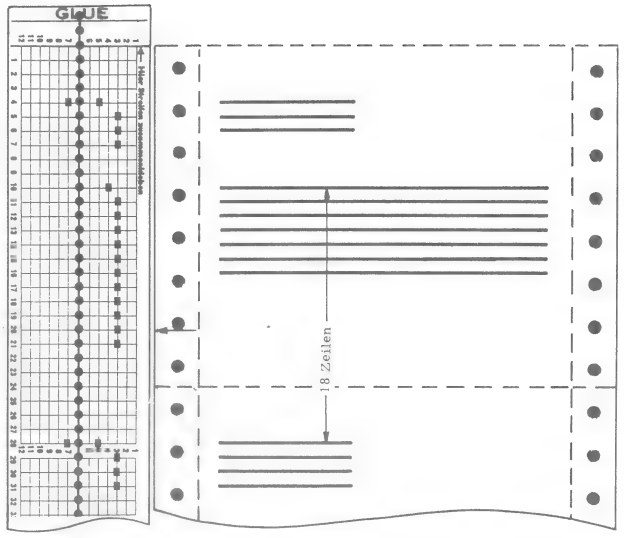
Skip To 3 is wired from CCI; the connection from Tape Exit 3 to Carriage Stop is not required.

The CCI impulse (A impulse) is suitable for wiring Card cycle spacing by method B for the following reasons:

1. The Skip To 3, 4, 5 hubs should preferably be impulsed by A and B impulses (see Timing Chart), although cycle impulses are also permissable.



No. 11



No. 12

2. Although the CCI hub also emits while the first card is being read at first reading, no undesirable skip or space will occur in this cycle because the Skip To hubs do not accept at this time (see Timing Chart).

Channel 3 was chosen because channels 4 and 5 have priority over it and are needed, for example, for the skip from the last detail card (in the middle of a form) to the total line (see example..)

No. 12 Skipping for Group Control Change without Program

This example corresponds roughly to examples 3 and 4: a form 4 inches (10, 2 cm) in length consists of a heading portion (1 - 4 lines) and a body part (1 - 12 lines possible). It is assumed that not more than 12 detail cards can occur. The longest skip will be 18 lines long.

The heading cards differ from detail cards in having an X punched in column 5. For simplicity, it is assumed that no other punches are present in this column.

This wiring has an advantage over wiring 3, because comparing (group control) is wired, even though there is no program, so that the carriage control cannot get out of step.

Control Panel Connections

1. Columns 1 - 4 are wired for group control.

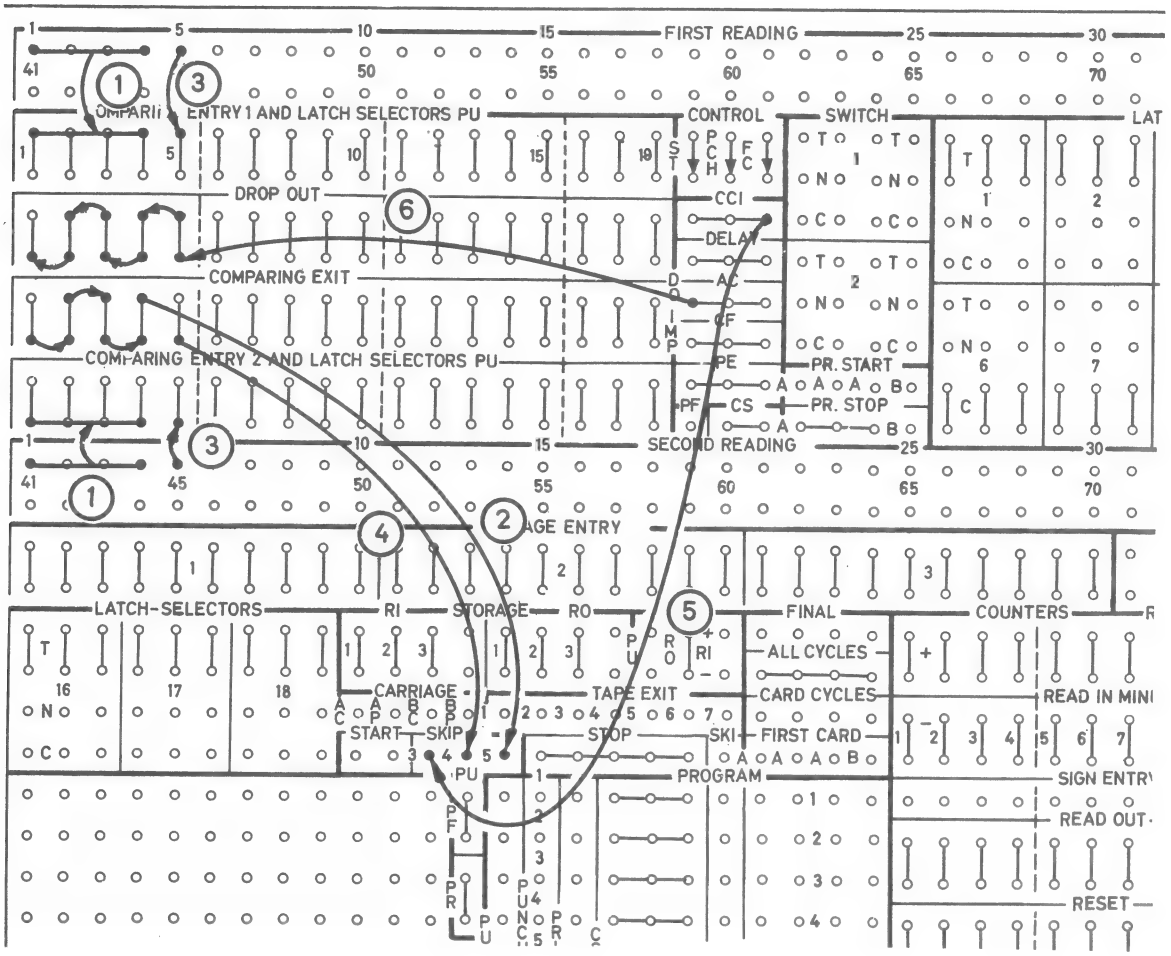
2. In the cycle in which the last detail card of a group is printed, Comparing Exits 1 - 4 emit a B impulse to Skip To 5, so that after printing this card, the form is skipped to the first heading line. Channel 5 has priority, so that this occurs in spite of any impulses to the other two hubs.

3. Latch selector 5 provides a sort of group control for X punches in column 5: it is transferred when the last heading card or the last detail card is printed.

4. Comparing Exit 5 emits a B impulse twice during the printing of a form: once each in the cycles in which the last heading card and the last detail card are being printed. The first of these two impulses causes a skip to the punch in channel 4 (first detail line), the second has no effect because here the Skip To 5 hub is impulsed at the same time.

5. The normal line space is caused by the CCI impulse wired into the Skip To 3 hub.

6. Latch selectors 1 - 5 are dropped out at the beginning of every cycle by the Drop Out - All Cycles impulse. The PE hubs cannot be used because no program takes place.

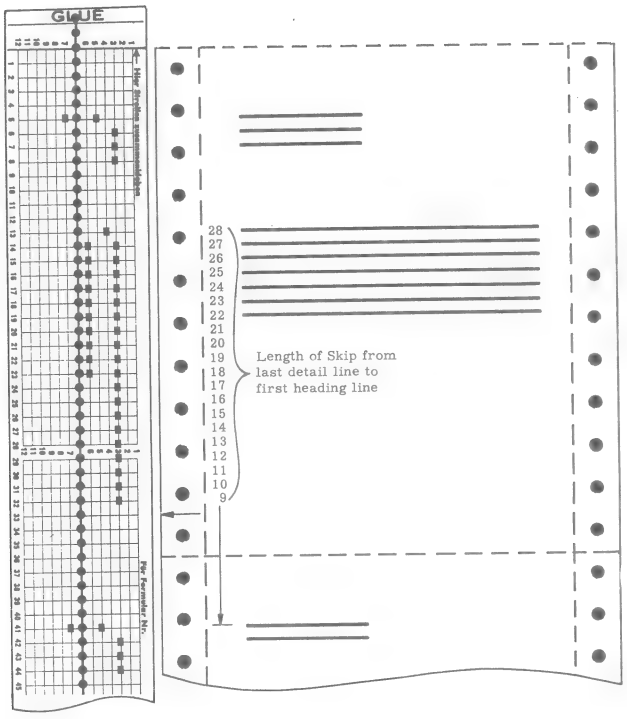


No. 12

No. 13 Skips of more than 18 lines

This example differs from the preceding, principally because the form is longer (6 inches as against 4 inches) and therefore skips of more than 18 lines can occur.

It is assumed that there are not more than 20 detail cards for each form. Depending on the number of detail cards, skips of between 9 and 28 lines occur on each invoice.



No. 13

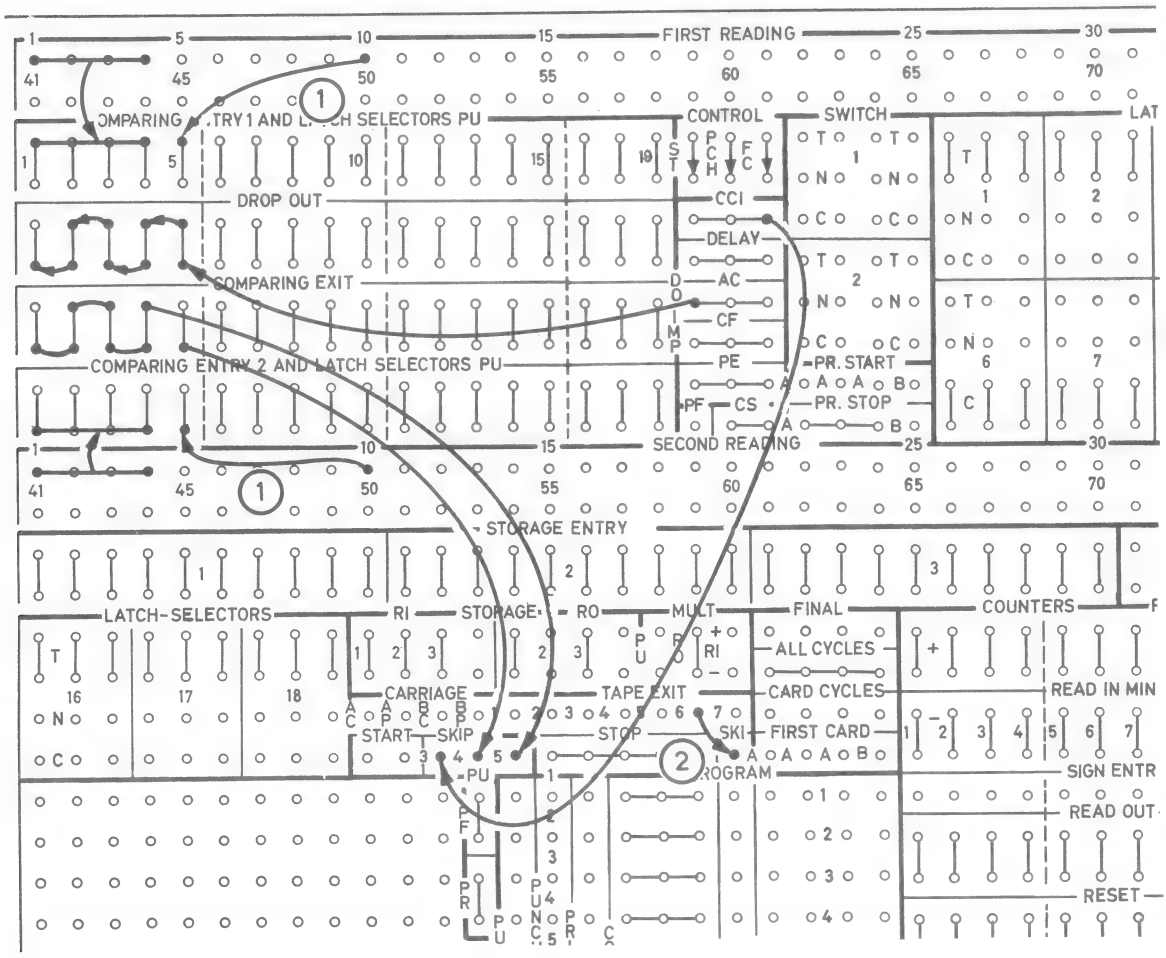
Control Panel Connections

1. The identifying punch (X or any desired, constant punch in column 10) in detail cards, for variety, is wired for comparing by latch selector 5. The operation is the same as that of connection 3 in example 12.

2. Tape Exit 6 is wired to SKI.

Control Tape

Channels 3, 4, 5 and 7 are punched exactly as in example 12. Channel 6 contains punches in lines 14 - 23 for skip interlock. In channel 6, line 13 should not be punched because this line of the tape will be sensed at about digit 12 time, at the end of the skip between the heading and the first detail line. Such an impulse would cause an interlock, erroneously, at the beginning of the cycle in which the first detail card was printed which, in this special case, would lead to burning of the relay contacts.



No. 13

Combined Wiring Examples

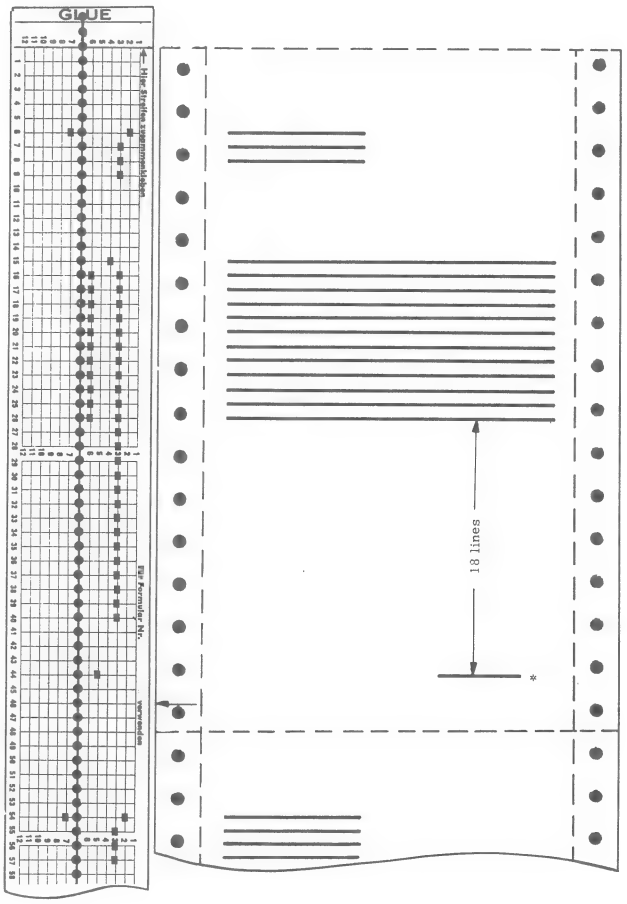
When skips of both types (Methods A and B) are combined in one wiring and the different means of control (Comparing, identifying punches, card cycles, first card, program cycles, overflow, and so on) are employed, there are often many solutions to a given problem. In practice, the solution requiring the fewest selectors and the simplest planning will be chosen.

No. 14 Predetermined Total Line (Solution 1) Selector Control

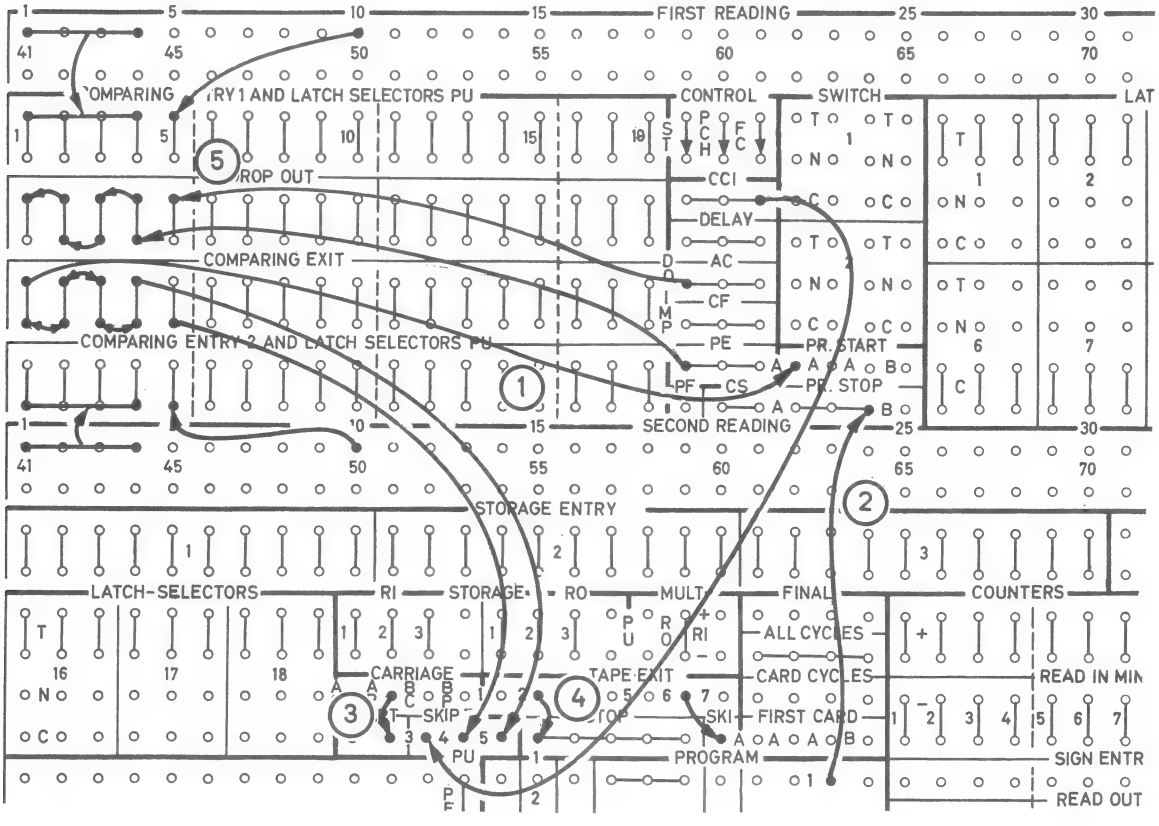
This example is only slightly different from the preceding: the form is 18 inches (20, 3 cm) long, contains 25 detail lines and one predetermined total line, which is printed during a program.

Control Tape

The arrangement of the control tape is very similar to the preceding example: channel 5 is not punched in the first heading line, but is punched in the total line. From the point of view of skipping, it is the same: in both cases the total line is to be printed the cycle after a change of group is detected. The first heading line is reached by a skip after the program. Carriage movement is



No. 14



No. 14

initiated by an impulse from the Carriage AP hub and is ended by a punch in channel 2.

Control Panel Connections

Only those connections which differ from those of the preceding wiring are described below:

1. On a change of group, Program Start A is impulsed together with Skip to 5.

2. The program consists of only a single step.

3. The impulse from Carriage AP to Carriage Start causes a skip to the first heading line after the program.

4. The connection between Tape Exit 2 and Carriage Stop can be made directly because only one channel is wired for method A operation. For the other skips (by method B) the carriage stop hub is inoperative.

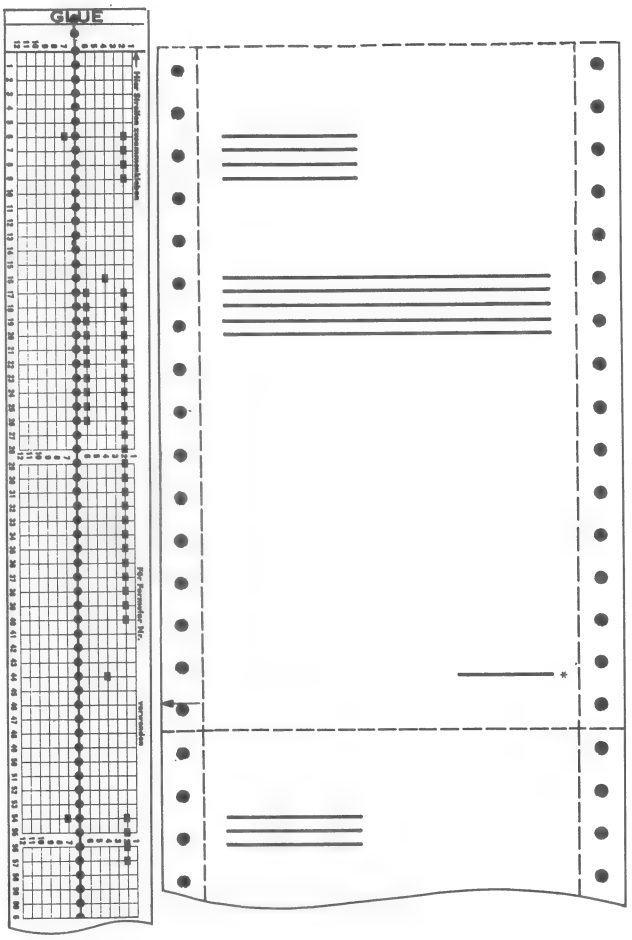
5. Because programs take place in this example, the PE impulse can be used to drop out latch selectors 1 - 4. Latch Selector 5 must be dropped out in every cycle, as before.

No. 15 Predetermined Total Line (Solution 2)

The output format of example 14 can be obtained in another way. Here the number of connections is the same, but one fewer tape channel is required. Which solution is used in practice will depend on other wiring requirements.

Control Tape

The complete spacing and the skip from total line to first heading line are controlled here by method A (channel 2). It should be noted that in the previous example the SKI hub was also impulsed for spacing, after printing lines 16 to 25. The machine did not take idle cycles, however, because the "skip" was completed after only one line.

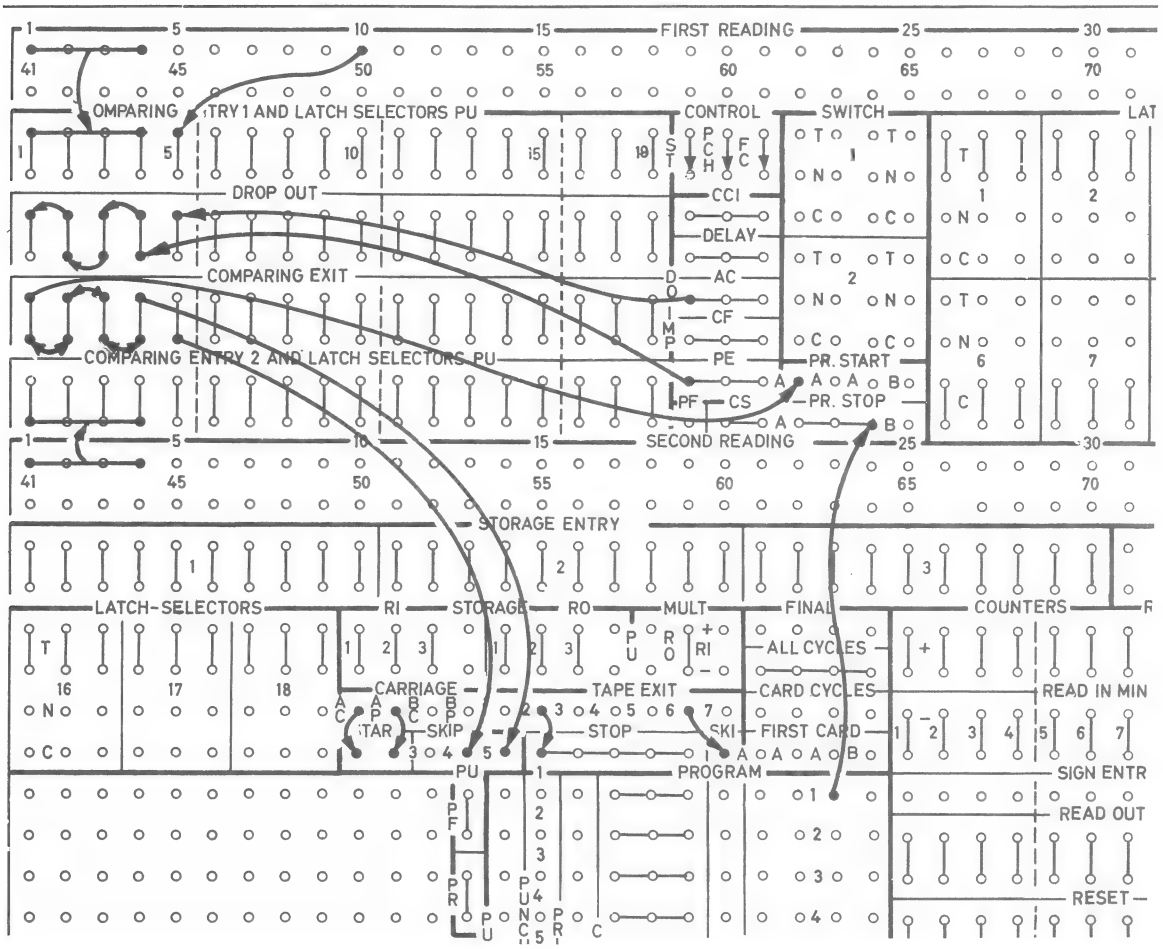


No. 15

Here, the SKI hub does not accept at all during spacing and only does so in skips of more than 18 lines. In operation, both methods are the same.

Control Panel Connections

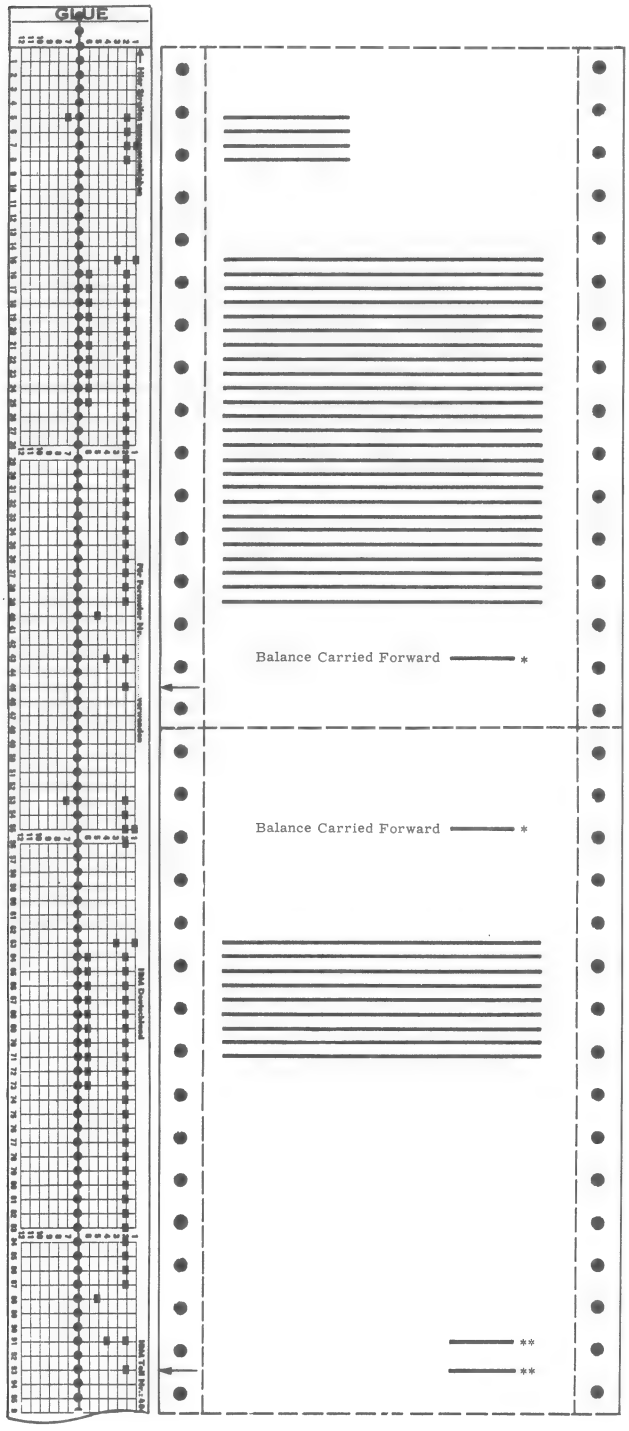
Instead of wiring CCI to Skip to 3, Carriage AC is wired to Carriage Start.


FIRST READING
OMPARING
TRY 1 AND LATCH SELECTORS PU
CONTROL
SWITCH
DROP OUT
CCI
DELAY
COMPARING EXIT
AC
CF
COMPARING ENTRY 2 AND LATCH SELECTORS PU
PE
PR. START
PR. STOP
SECOND READING
STORAGE ENTRY
LATCH-SELECTORS
RI
STORAGE
RO
MULT
FINAL
COUNTERS
ALL CYCLES
CARD CYCLES
READ IN MIN
CARRIAGE
TAPE EXIT
FIRST CARD
SKIP
STOP
PROGRAM
SIGN ENTR
READ OUT
RESET

No. 1

No. 16 Overflow

In this application, the preceding example has an overflow program added to it. If more than 25 detail cards are present for one invoice, a running total will be printed on the total line of the first form and also on the third heading line of the next (Program Step Rows 1 and 2). Following this, the remainder of the detail cards are printed. After the last detail card has printed, a normal program (Program Step Rows 5 and 6) takes place, in which the totals of both batches are printed, on the predetermined total line.



No. 16

Control Tape

Most spaces and skips are ended by punches in channel 2. Channels 3 and 4 fulfil the same functions here as channels 4 and 5 in the preceding example. Channels 6 and 7 remain unchanged. The 43rd line of the form (first total line or balance carried forward) can be reached in three ways:

1. When fewer than 25 detail lines are printed on the form.
2. When exactly 25 detail cards are present.
3. When more than 25 details cards are present.

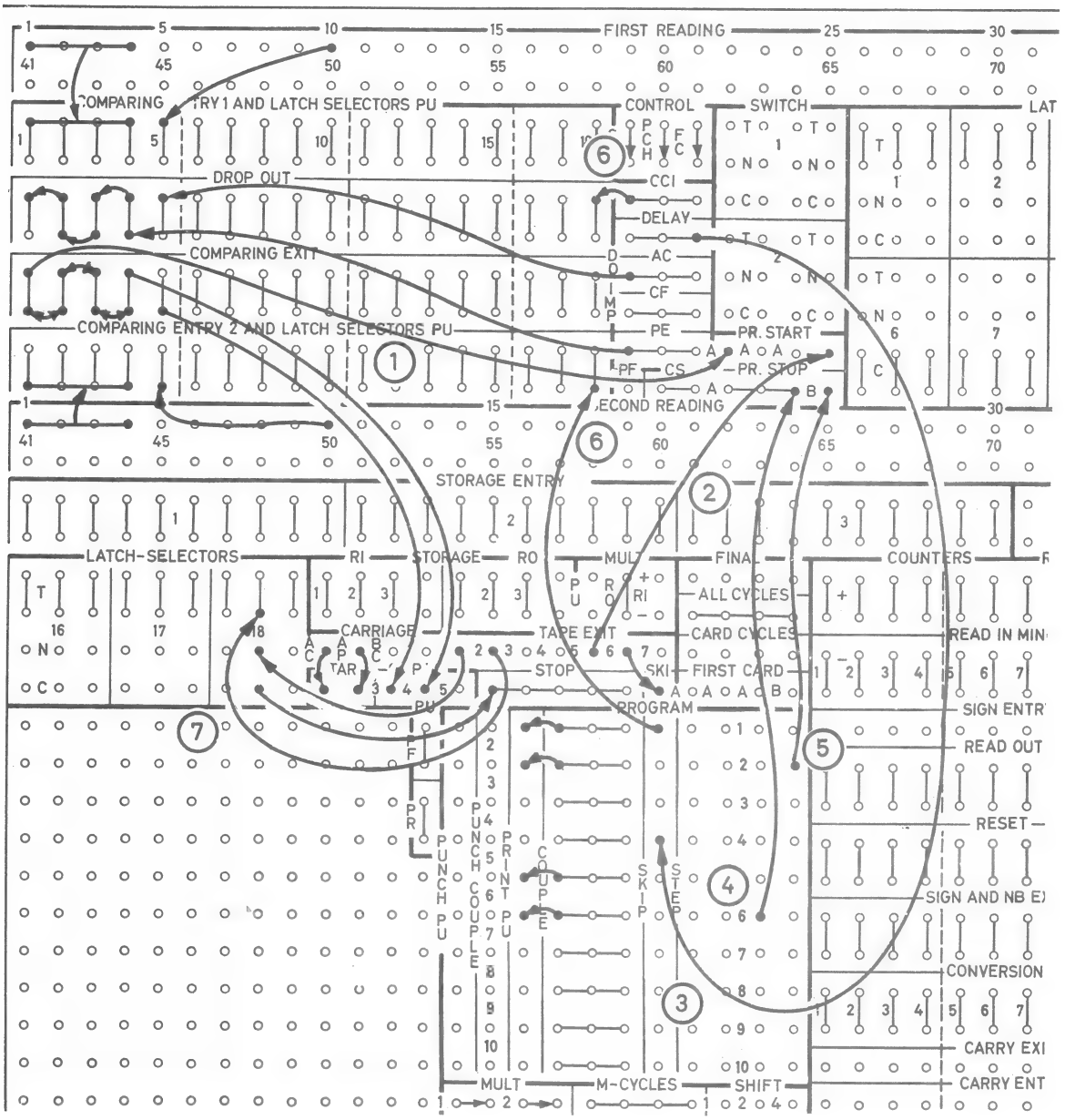
In the first two cases, the group changes and the 43rd line is reached by a skip to 4, so that the punch in column 5 on the 40th line of the tape is not sensed.

In the third case, the group does not change so that this line is reached through a normal skip in channel 2 and therefore Tape Exit 5 emits an impulse to Program Start B.

The punches in channel 1 are used to position the running total at the head of the form and the first detail line, in the event of an overflow program.

Control Panel Connections

1. On a change in group control number, Program Start A is picked up with a B impulse from Comparing Exits 1 - 4.
2. On an overflow condition, Program Start B is picked up from Tape Exit 5, shortly after C impulse time.
3. Program Skip 4 is impulsed with a B impulse in in all cycles, but is only operative when a program is picked up at the same time or earlier. As a consequence of this, the first four program rows will be suppressed for an A level program (picked up at the same time, with a B impulse), but will not be suppressed in a B level program (picked up shortly after C impulse time), so that the program commences with Program Step Row 1.
4. The main program consists of two steps, in which two totals are printed.
5. The overflow program also consists of two steps, in which the running total is printed twice.



No. 16

6. Latch selector 18 is picked up by a B impulse in the first cycle of an overflow program and remains transferred until A impulse time, in the next card cycle.

7. During the overflow program, latch selector 18 switches carriage stop from channel 2 to channel 1 for the length of two cycles so that the two carriage movements will be stopped at the running total line at the head of the form and at the first detail line.

Wiring Hints

The IBM 3000 combines a large number of functions (amongst others: card reading, card punching, card selection, programming, counter and storage functions, printing), all of which can be governed by the control panel. This gives the machine a considerably greater flexibility than earlier accounting machines.

With a good knowledge of the machine and attention to the hints and rules, it is not difficult to expand the range of application of the machine far beyond the typical examples given in this manual, by combining many of the wiring possibilites.

In cases of doubt arising in the developement of these wirings, the Timing Chart is of prime importance as it shows in the clearest way possible the different impulses which may be used to pick up individual functions. The following rules for using this should be observed:

1. Different types of exit impulse should not be wired together.
   For example: If the Carriage AC and BC (Q/10 and 12) are wired together, the "12" hub of the digit emitter (AE-AF/1) emits a spurious C impulse in card cycle print cycles which can lead to error if certain functions are to be controlled by a 12 impulse.

   However, impulses of the same type can be wired together, for example Card Cycle and Program Step Impulses, if the same functions are required in card cycles and also in certain program steps.

2. An entry hub may only be impulsed with those impulses shown on the timing chart as being suitable. If one of the other impulses are used, one of three things may happen:

   a) The impulse has no effect.
      For example: The Carry Entry hubs (AC/25-36) only accept A or B impulses. Other digit impulses ineffective; long impulses (for example All Cycles Hold impulses - AJ/23-28) will damage the counter.

   b) Machine Operation is uncertain.
      For example: Multiplication must not be picked up by a 12 impulse, otherwise incorrect results will be produced.

   c) The machine will be damaged.
      For example: If the SKI (Skip Interlock - R/20) hub receives a 12 impulse or a carriage impulse shortly before 12 time, a relay contact inside the machine will be damaged by arcing. In a short time this would result in the machine being unable to take print cycles.

3. A connection should not be made through a selector in such a way that arcing can occur as this can destroy the contact.
   For example: If a Cycle Hold impulse is taken through the Normal of a latch selector and the latch selector is picked up by an X impulse, arcing will occur because the circuit will be broken whilst current is actually flowing.

   However, there is no restriction on allowing a circuit to be made during an impulse time; the hold wiring of co-selectors makes use of this.

The various types of cycle distinguished in the Timing Chart are to be understood as follows:

The four kinds of card cycle (C 1, C 2, FC and LC) are not mutually exclusive. It is in fact possible for all four kinds of card cycle to occur simultaneously, if for example a single card group appears during a run. Then, there is a card feed cycle, with a card at first reading and another at second reading, which is the first card cycle after a program and is also the last card cycle before the next program. Therefore the timing chart should be used, not so much for deciding which impulses are available in a given type of cycle, but rather to begin with a given hub or impulse and to check the types of cycle in which it is available.

For example: The hubs PR Start A (Program Start A) have an X in the FC column only. This means merely that the card cycle in which program start is picked up is the last card cycle before the program; it does not mean that Program Start A could not be picked up in, for example, a first card cycle after a program.

For program cycles the case is somewhat different: here the columns P (all program cycles except the last) and LP (last program cycle) are mutually exclusive. If, for example, there is only a single step in the program, the first and the last program cycles are one and the same cycle. In this case, only the impulses given in the LP column are available. Therefore, Program Skip 1, for example, does not emit in a single step program.

Wiring Examples

Wiring No. 1

List printing with field selection

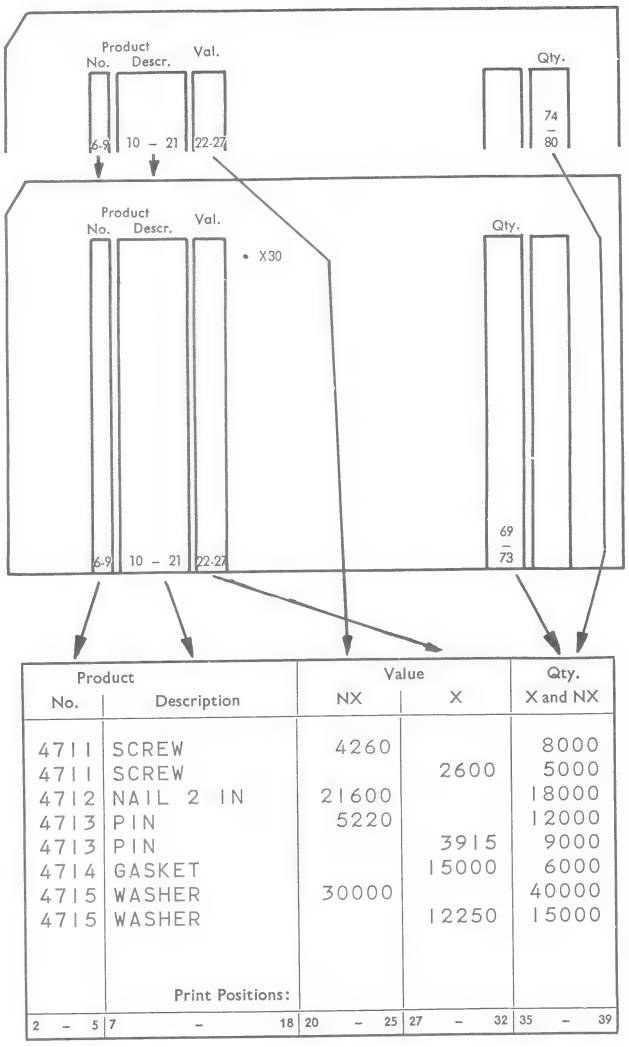
The arrangement of fields in the card rarely corresponds to the layout of the printed form. For example, whereas the individual print fields on the form are separated by spaces, fields in the punched cards are not separated by blank columns.

By control panel wiring, any column of the card can be wired to print in any print position. This permits the form design to be completely independent of the card layout, especially if the printing is varied by selectors controlled by a card code.

This allows two possibilities: printing the same card field in one of two print fields, depending on the class of card ("class selection"); or printing in one place from either of two different card fields ("field selection").

One of the two classes of cards must bear a control punch so as to differentiate it from the other class of card. When it is only a question of printing numerical information, the control of selection can be done by an 11 or 12 punch. If alphabetical information is to be selected, any desired control punch in a column can be used.

In the following example both field and class selection are shown. One class of card is differentiated from the other by an identifying punch in column 30.



Product No.	Description	Value NX	Value X	Qty. X and NX
4711	SCREW	4260		8000
4711	SCREW		2600	5000
4712	NAIL 2 IN	21600		18000
4713	PIN	5220		12000
4713	PIN		3915	9000
4714	GASKET		15000	6000
4715	WASHER	30000		40000
4715	WASHER		12250	15000
	Print Positions:			
2 - 5	7 - 18	20 - 25	27 - 32	35 - 39

1. The product number in columns 6 - 9 is to be printed for both classes of card in print positions 2 - 5 and can so be wired directly.

2. The product description in columns 10 - 21 can likewise be wired directly to print positions 7 - 18.

3. An X in column 30 picks up co-selector 2.

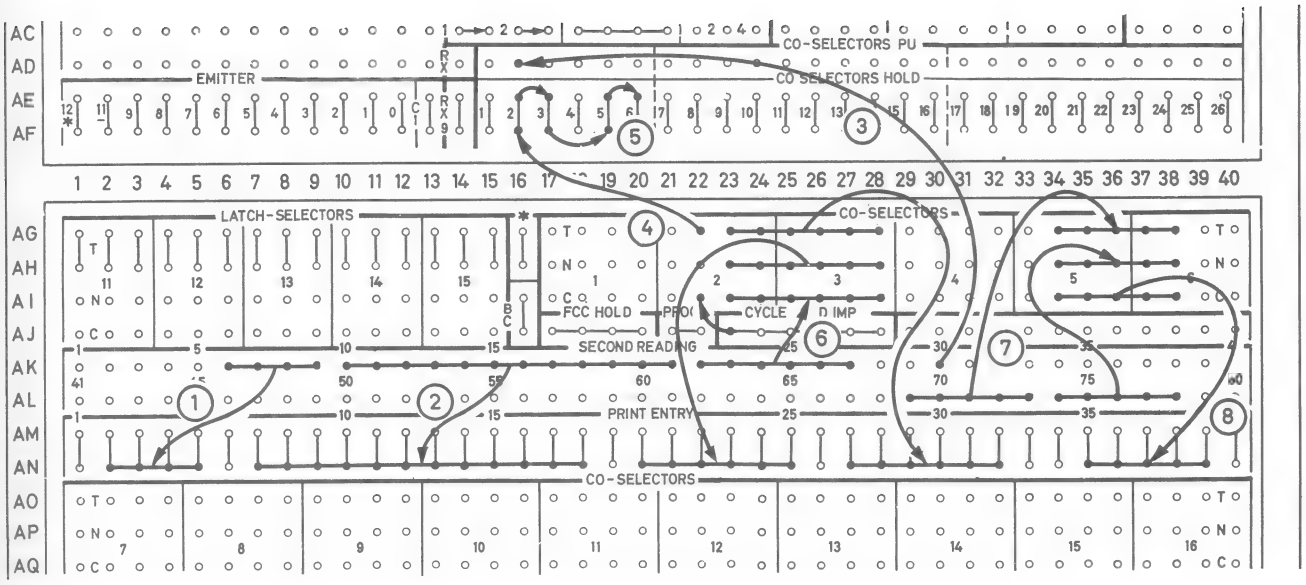
4. Co-selector 2 is held by a Cycle Hold impulse.

5. Co-selectors 3, 5 and 6 are coupled to co-selector 2.

6. The "value" field is to print in print positions 20 - 25 for cards without an X and in print positions 27 - 32 for cards with an X.

7. The quantity is punched into columns 69 - 73 of X cards and into columns 74 - 78 in no X cards. These card fields are wired into the Transferred and Normal sides respectively of coselectors 5 and 6.

8. The Common points of coselectors 5 and 6 are wired to Print Entries 35 - 39. In this way, both card fields will print in the same position on the form.



Wiring No. 1 List printing with field selection

Note:
This is not the complete wiring. The wiring of run control and the carriage is not shown.

Wiring No. 2

Alphabetic field selection

Field selection of numerical information was shown in Wiring No. 1. There it was possible to pick up a selector at the correct time by means of an 11 punch read from the second reading station. This will not do for alphabetic information; here the command for selection must be given in the preceding card cycle whilst the X card is passing First Reading. The necessary delay is achieved by picking up a latch selector from First Reading and then picking up a co-selector with the B impulse emitted from the Comparing Exit. The co-selector is held by means of an FCC Hold impulse (Following Card Cycle Hold) until 240° in the next card cycle.

1. Address cards are punched with an X in column 1.

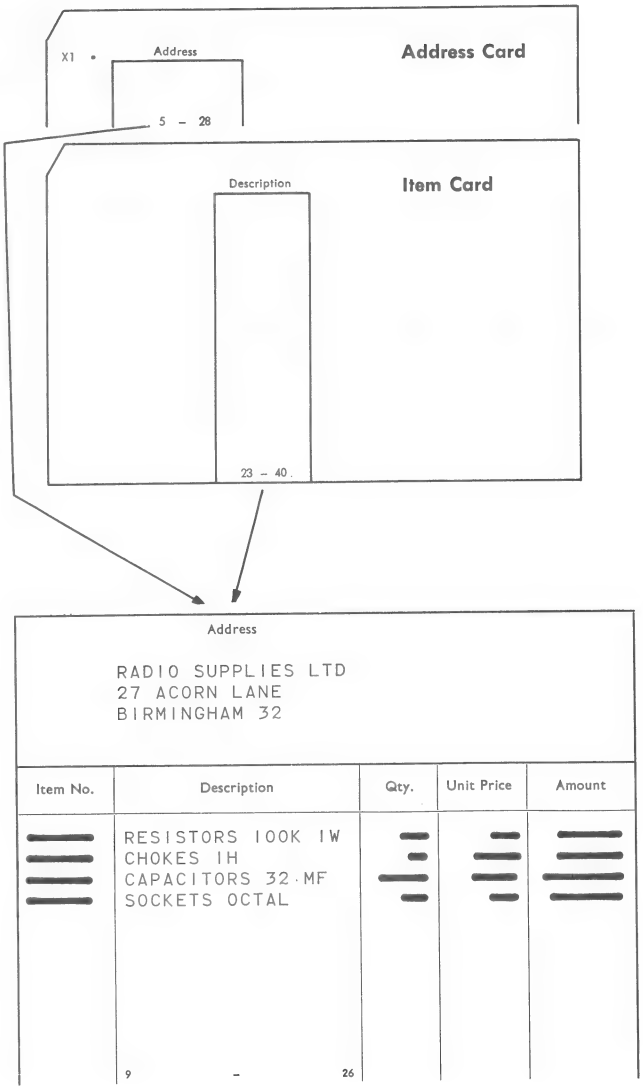
2. Co-selector 4 is used as a column split, so that 11 and 12 impulses can pass through the Transferred side to latch selector 15 Pick-up hub.

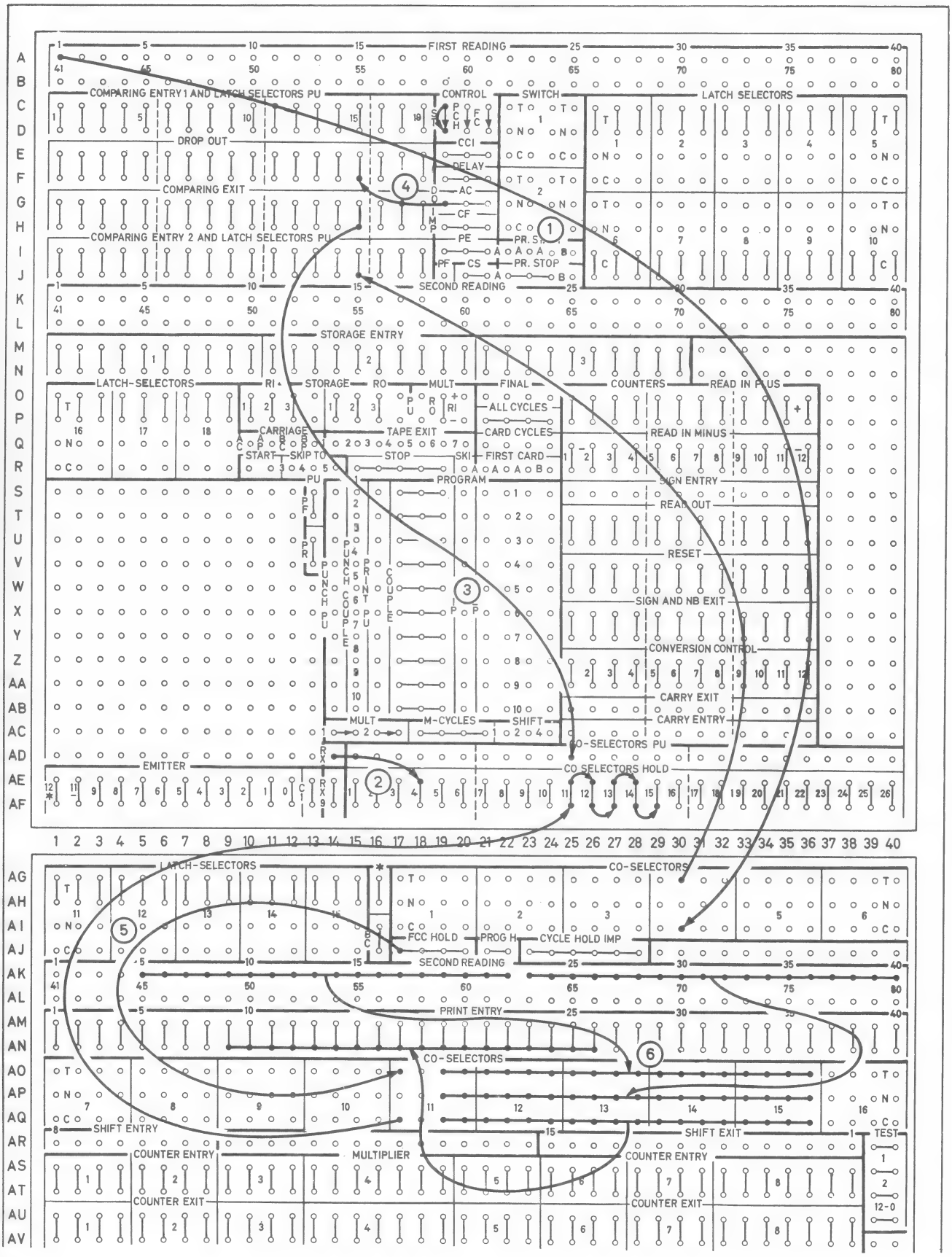
3. If an X card passes First Reading, Comparing Exit 15 emits a B impulse which is wired to the pick up hub of co-selector 11.

4. Latch selector 15 is dropped out at the end of every cycle.

5. If co-selector 11 is picked up by a B impulse, it will be held through one of its own Transferred contacts until 240° in the next card cycle (even if there is an intervening program). The hold impulse is also chain-wired to co-selectors 12 - 15.

6. In address cards, the address field is punched into columns 5 - 22; in item cards, the item description field is punched into columns 23 - 40. These two fields are brought together by co-selectors 11 - 15 and print in print positions 9 - 26.





Wiring No. 2 Alphabetic field selection

Print Cycles

Normally, every card cycle is a print cycle; that is, all cards passing through the machine will be printed (list cycles). If the Tab key is depressed, cards are fed without being printed (tabulate cycles). This may be used in duplicating and gang punching operations or when performing check runs. In some tabulating operations the first card of a group has to be printed (first card print cycle). In order to achieve this, the Tab key must be depressed and the Control FC switch jackplugged. It is also possible, however, to print certain cards, identified by a control punch, in a deck and to suppress printing for the other cards (selective list cycle). Selective listing can be wired in three different ways on the IBM 3000 Accounting Machine. In each case the Tab key (No. 9) must be depressed.

Wiring No. 3

Selective listing, method 1

This is the normal way of wiring selective listing:

1. Cards which are to be printed contain an identifying punch in column 1. When this identifying punch is sensed at First Reading, a print cycle must be initiated for the next card cycle (in which this card passes Second Reading). The necessary cycle delay is achieved by using latch selector 6 and co-selector 1.

2. The B-impulse from the Comparing Exit of latch selector 6 is wired to pick up co-selector 1, which is held by an FCC Hold impulse.

3. The co-selector is thus transferred until 240° in the next card cycle (and through any intervening program) and can select an E-impulse from the RX hub to the PR PU (Print Pick-up) hub to cause the card cycle to be a print cycle.

4. Latch selector 6 is dropped out by a D-impulse from the AC hub at the beginning of every cycle.

5. The Control FC switch need only be wired if, besides the selective list cycles, a print cycle is required for every first card after a program.

6. The Carriage AC, AP, BC, BP impulses are only emitted in print cycles, so that in non-print machine cycles no skips take place (see however, Wirings 4 and 5).

7. The connections from Second Reading to Print Entry are wired to give the desired printed format.

Wiring No. 4

Selective listing, method 2

This method differs in minor details from the preceding. The use of selectors is unchanged. The cycle delay is achieved through latch selector 6 and co-selector 8.

1. Here a D-impulse from the CF hub, instead of an E-impulse, is taken through co-selector 1.

2. When the lower hub of the Control FC switch receives a D-impulse, a print cycle will take place in that same cycle. (This hub is normally wired from the hub immediately above it, which emits a D-impulse in the first card cycle after a program).

3. This wiring has an advantage over the preceding in that the three First Card A hubs emit in each print cycle. Thus carriage movement can here be controlled by a First Card A-impulse to Skip To 3. Carriage Stop need not be wired in this case (it should be noted that this hub can cause a skip even though there is no print cycle taking place).

4. If certain amounts are to be entered in the counters only from those cards which are to be printed, counter read in can be controlled by a First Card A-impulse.

Wiring No. 5

Selective listing, method 3

This wiring differs from the preceding in that only one selector is needed. It may only be used, however, when no program is required.

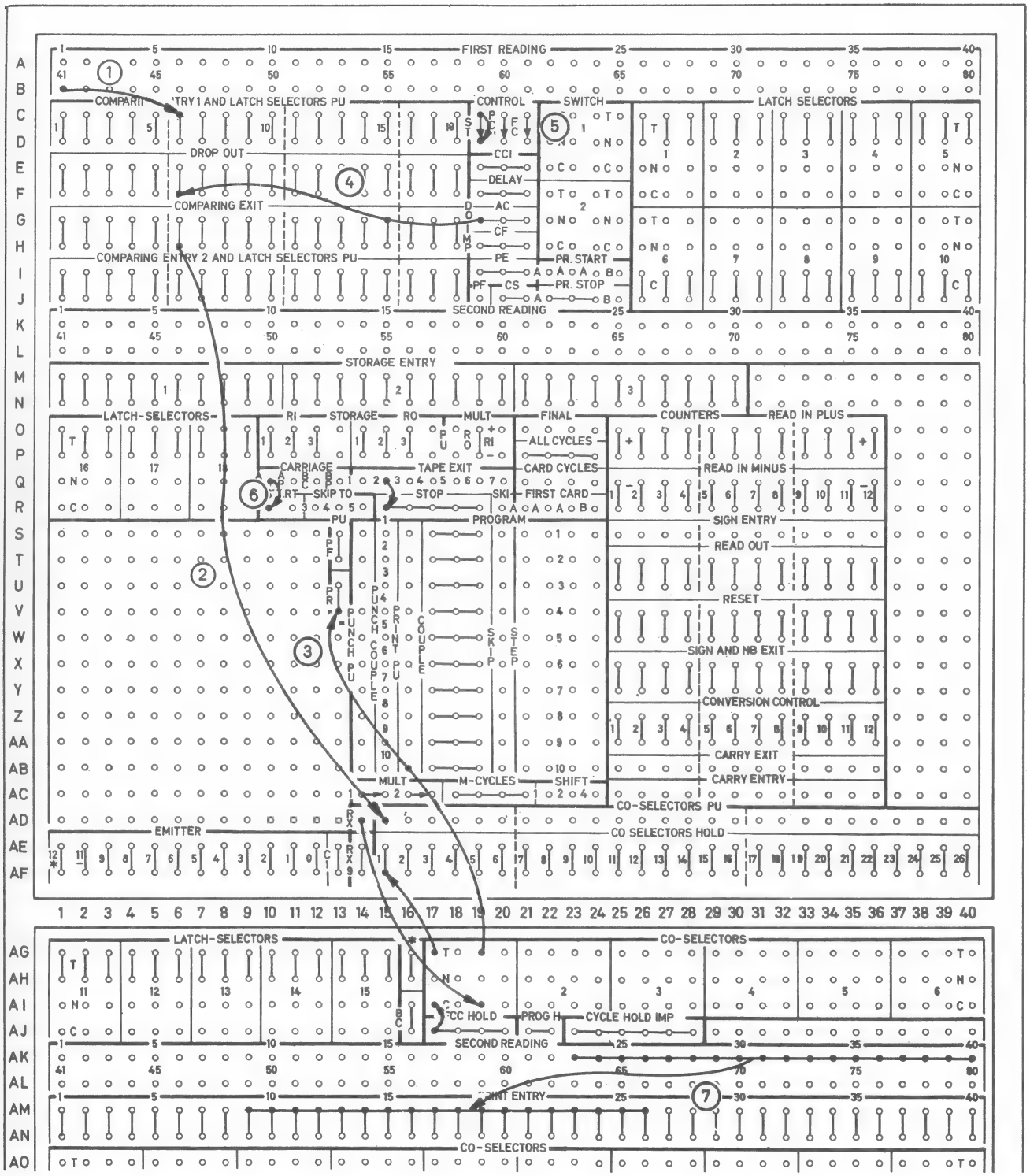
1. Latch selector 6 is picked up from column 41 at First Reading.

2. An A-impulse from the CCI hub is wired through the Transferred side of this selector.

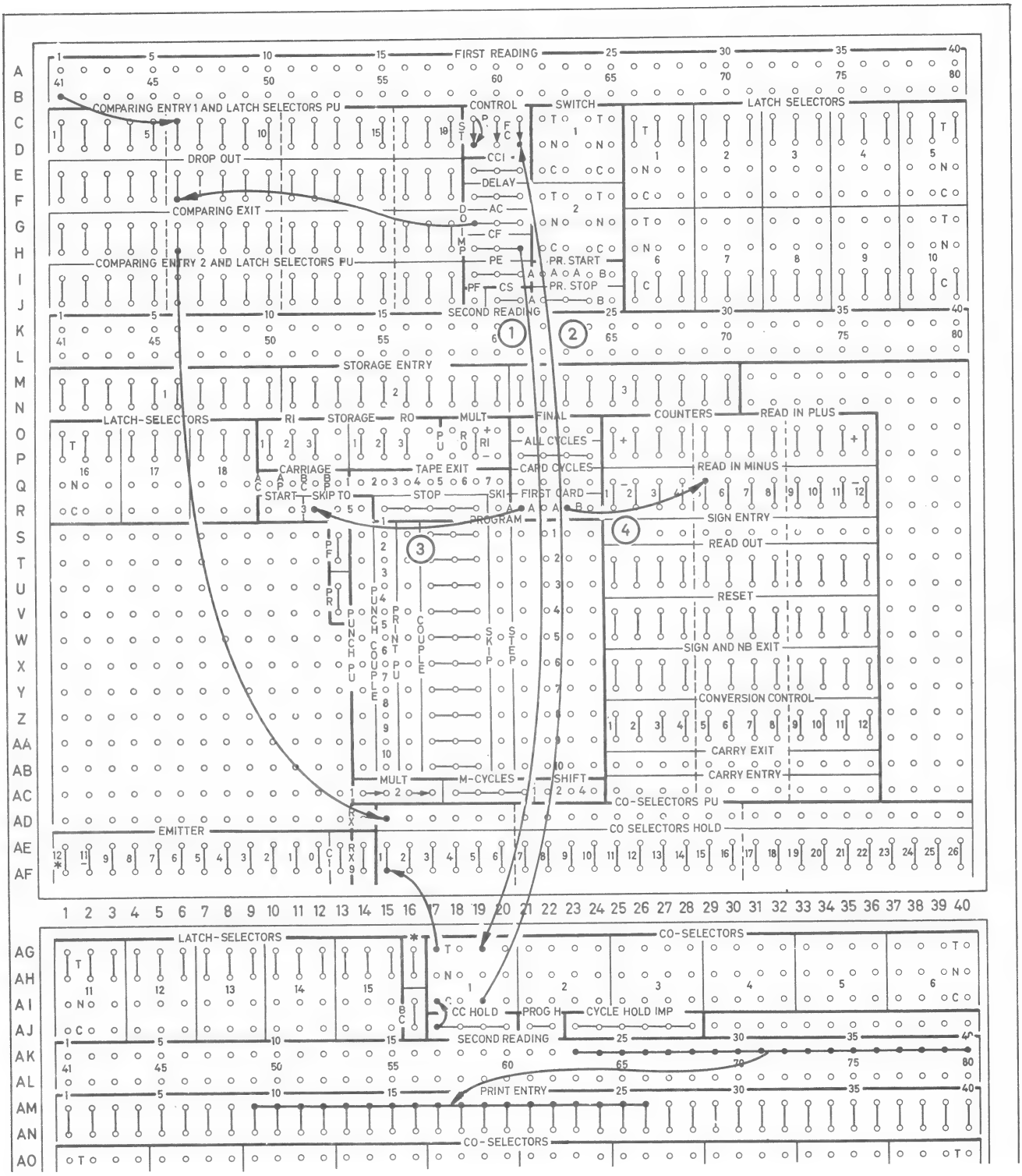
3. The Control FC switch must be jackplugged for this wiring.

4. If the Program Stop hubs receive an A-impulse, the following card cycle will be a print cycle, even though Program Start has not been picked up.

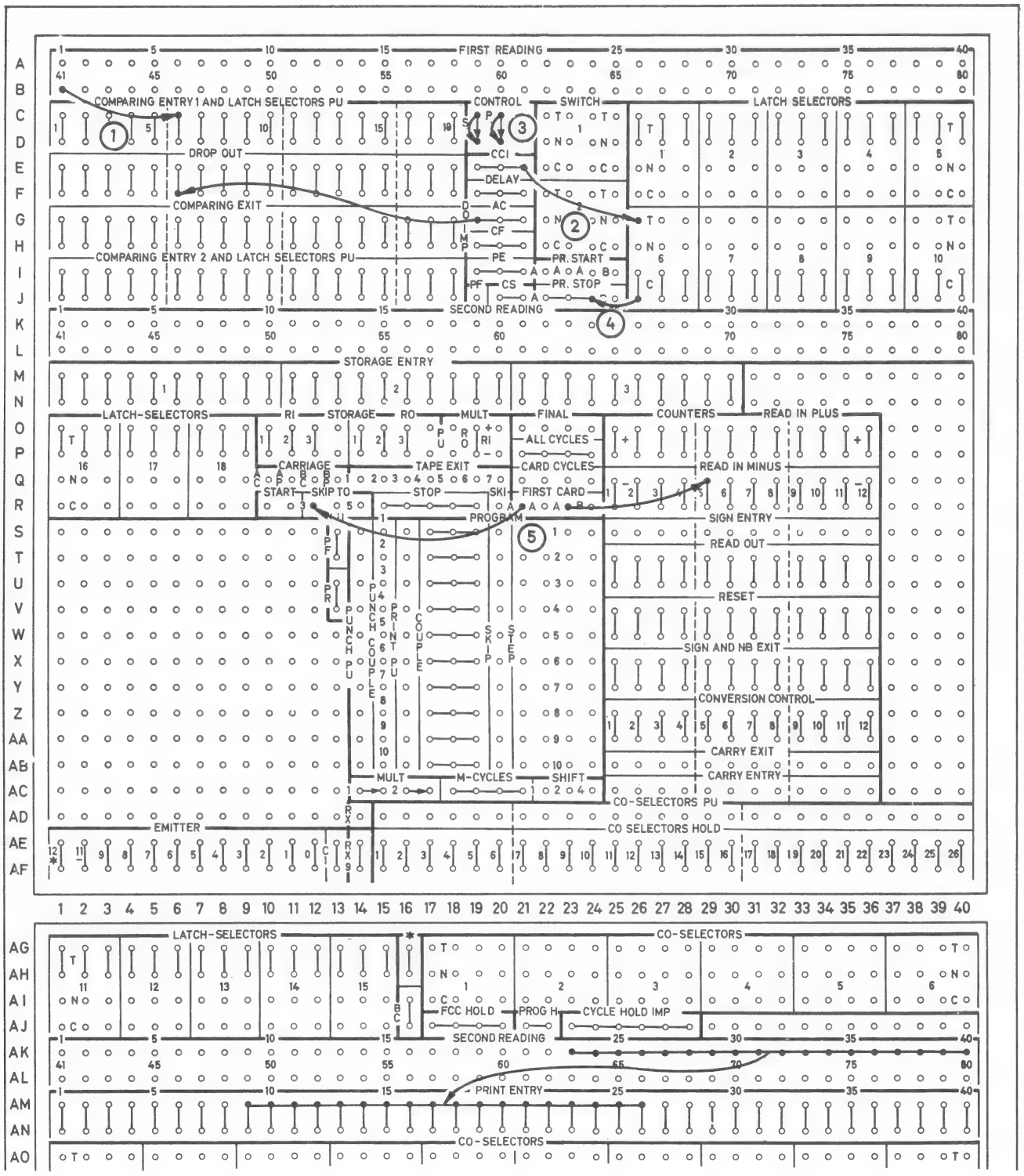
5. The First Card A hub emits, as in the preceding wiring, in every print cycle.



Wiring No. 3 Selective listing, method 1



Wiring No. 4 Selective listing, method 2

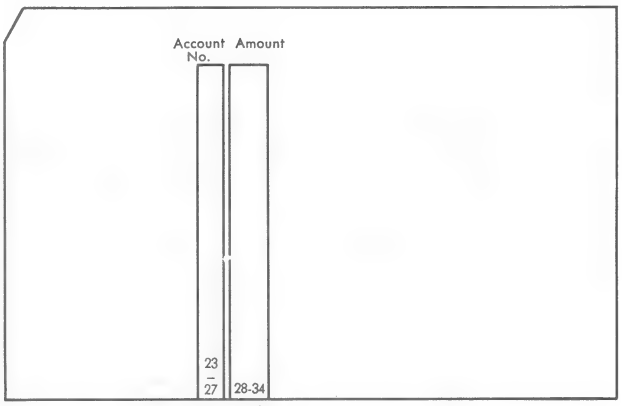


Wiring No. 5 Selective listing, method 3

Wiring No. 6

Accumulating and total printing

The following example shows the simplest application of the Accounting Machine, apart from simple list printing: the card contains a customer number and the amount. As cards pass through the machine they are printed. At the same time the amounts are added into a counter. When the last card has passed through the machine, a depression of the Final key will print the sum and reset the counter. Likewise, the Final key must be depressed at the beginning of a run in order to reset the counter.



Account No.	Amount (Total = *)
13455	325.35
13466	6732.12
13468	12.79
13512	17652.53
13519	3569.78
14125	71.25
14126	2529.75
14135	634.48
	31528.05*
Print Positions: 23 – 27	30 – 39

1. The customer number in columns 23 - 27 is printed by print positions 23 - 27.

2. The amount is read from columns 28 - 34 and wired to Print Entries 31 - 38.

3. An A impulse from the CI hub is wired to Print Entry 36 and effects the printing of a decimal point in all print cycles. Thus a point is printed between Dollars and Cents. It should be noted, that the point is printed in a numerical print position by an A impulse, but in an alphabetical print position by the 9/0 impulse combination.

4. The print positions are wired to both the Entry and Exit hubs of counters 6 and 7. Thus the printed amount can be read in to the counters and the accumulated sum can be printed from the same print positions. (This method of wiring entry and exit hubs in rows is sometimes known as "channel" wiring or "common" wiring).

5. Counter 6 (senior counter) is coupled to counter 7 (junior counter).

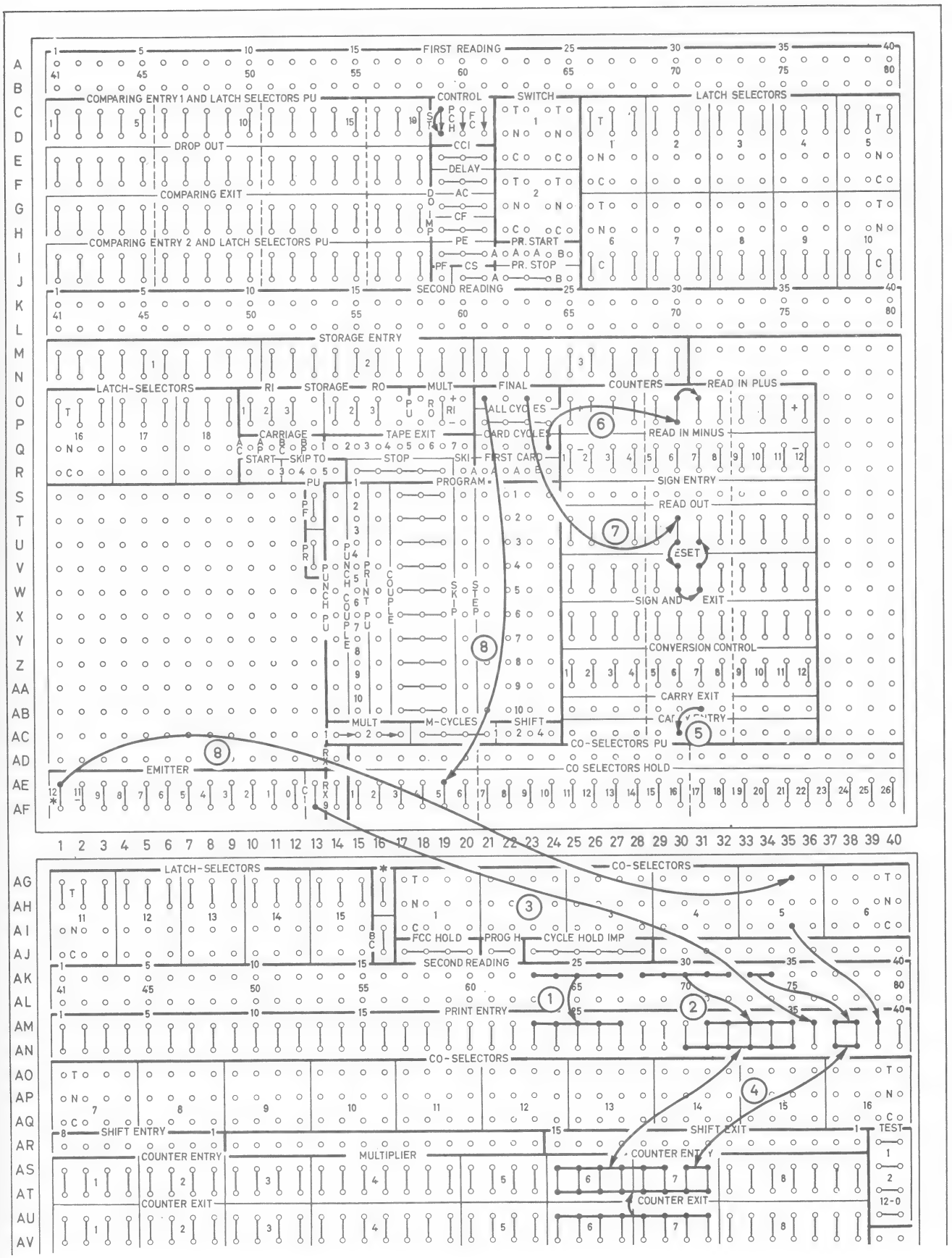
6. A card cycle impulse is wired to Counter Read In Plus of counters 6 and 7, so that the amounts are added in all card cycles.

7. After the last card has passed through the machine, a depression of the Final key will read out and reset counters 6 and 7.

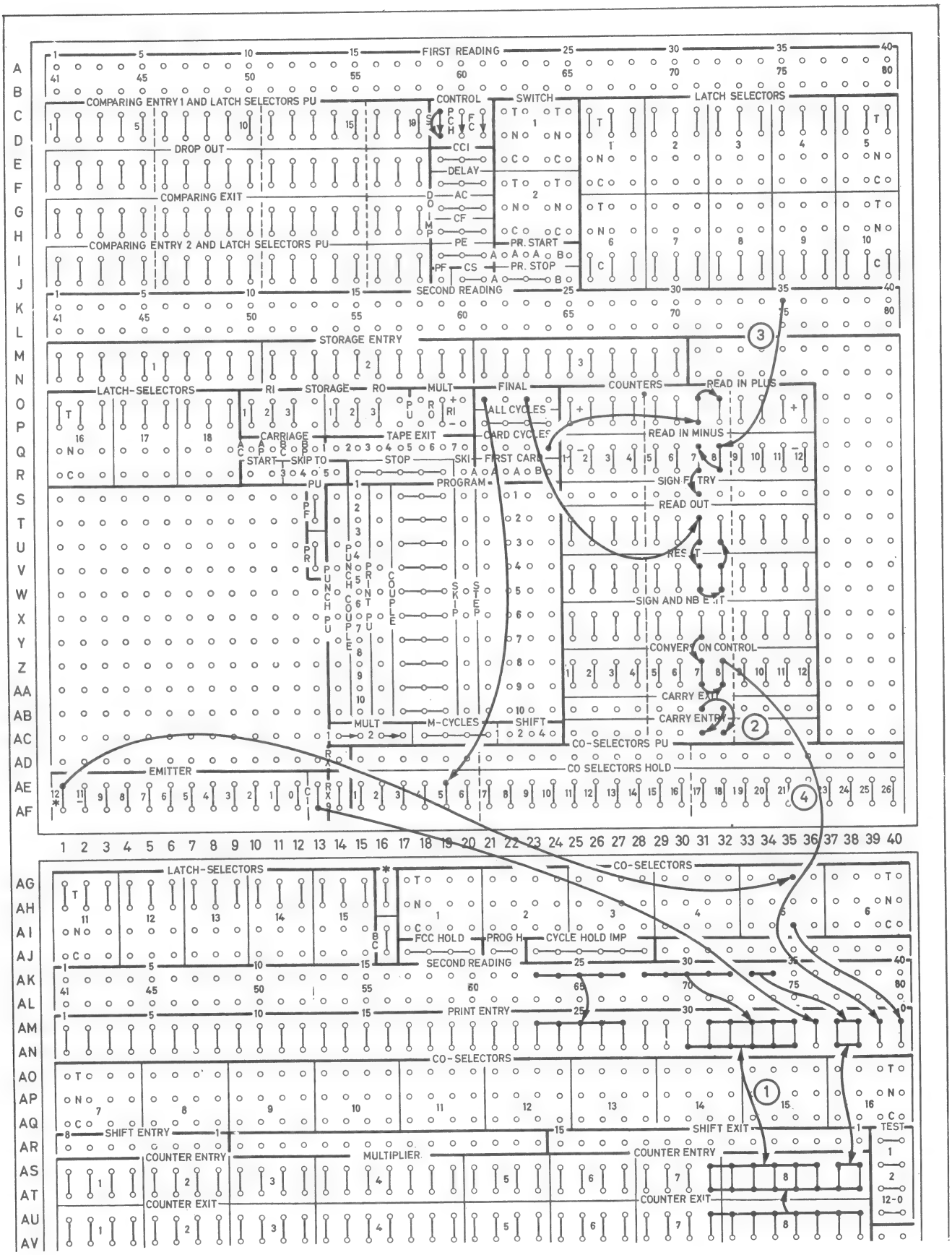
8. Co-selector 5 is transferred by a Final impulse. A 12 impulse is wired through the Transferred and Normal points of this selector to Print Entry 39, so that the final total is identified with an * symbol. Instead of this method of printing the total symbol, a 12 impulse could have been wired directly from the * (Program Cycle Symbol) hub.

Note:
This chart does not show the full wiring for this example; run control and spacing wiring must be added.

Note: the discussion of connection 3 is no longer applicable to machines of current production. These have an oblique stroke (/) corresponding to the impulse combination 9/0, in place of the decimal point (.) of earlier machines.



Wiring No. 6 Accumulating and total printing



Wiring No. 7 Balancing

Wiring No. 7

Balancing

This wiring differs from the preceding in that negative amounts may occur and so a balance has to be calculated.

1. In this case the balance may reach 8 positions; the counter capacity must be at least one position larger than this and so counters 7 and 8 are used here.

2. To allow subtraction to take place, the counter carry wiring must include a connection between the Carry Exit of the senior counter to the Carry Entry of the junior counter as well as the normal connection from the Carry Exit of the junior counter to the Carry Entry of the senior counter.

3. Cards with negative balances are punched with an X in column 25. This impulse is wired to Counter Read In Minus and causes the value to be subtracted. The X impulse is also wired into the Sign Entry hub of counter 7, but not into that of counter 8.

4. A minus sign (-) is printed by print position 39 for all X cards. As soon as an X in column 35 is sensed, a 11 impulse is passed through the sign selector (Sign Entry to Sign and NB Exit) to Print Entry 39. This internal connection through the sign selector is provided in all cycles in which the counter is not read out.

A minus sign must similarly be printed beside the final total if a negative balance results. In this case the 11 impulse comes directly from the counter out of the Sign and NB Exit hub, if the senior position of counter 7 contains a 9.

Wiring No. 8

Group control and transfer of group totals

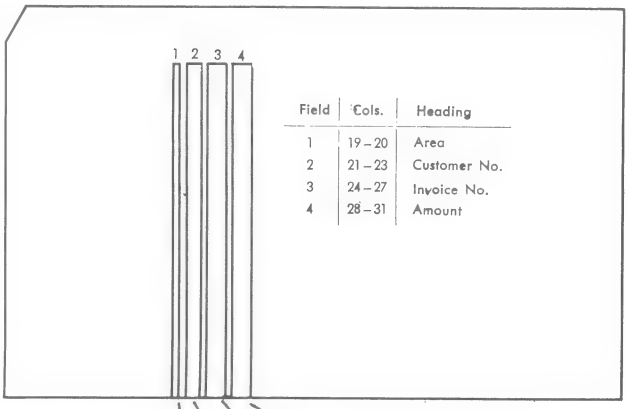
In this example Exception cards, sorted by customer number and area, are to be listed. The order numbers (area, customer number) and the indicative information (invoice number) are to be printed; the amount is likewise to be printed and at the same time accumulated in a counter. Totals by customer and by area are required. Thus two levels of group control (program) are wired, so that Program Start A is picked up on a change in customer number (minor group) and Program Start B is picked up by a change of area (major group).

On a minor change only one program step is required, in which counter 4 reads out the minor total to print, the counter is reset and this total is accumulated in counter 8.

On a major change, a second program cycle is needed, in which the major total is printed on the same line and the major counter is reset. Carriage movement for line spacing can, in this example, be achieved without the use of a tape: wiring a Carriage AC impulse to Carriage Start will cause a single space after every card. The double space between individual groups is obtained by impulsing Carriage Start with a BC impulse for every first card of a group.

Carriage movement during programs is a little more difficult. Since the major total is to print in the second program step on the same line as the minor total in the first program step, care must be taken to ensure that the AC impulse reaches Carriage Start only once in each program, during the first program step in a minor program and the second program step in a major program.

In contrast to the preceding wiring examples, the counters need not be reset before beginning a run: after the first card has been read at First Reading, a so called "ghost" program takes place in which all program functions wired, with the except-



Field	Cols.	Heading
1	19-20	Area
2	21-23	Customer No.
3	24-27	Invoice No.
4	28-31	Amount

Area	Cust. No.	Inv. No.	Amount *= Cust. Total	Area Total
12	136	4573	3040	
12	136	4678	2570	
12	136	5622	720	
			6330*	
12	137	4326	7220	
			7220*	13550
13	129	5637	4320	
13	129	6272	3270	
13	129	6273	5270	
			12860*	
13	147	2772	415	
Print Positions:	16-17	19-21	23-26	28-33	35-40

ion of printing and of carriage movement, are carried out. In this way the counters are reset by the time the first card reaches Second Reading.

Connections

1. Area number, columns 19 - 20, is treated as the major group (program level B).

2. Customer number, columns 21 - 23, is treated as the minor group (program level A).

3. Program Start A is picked up for every minor control change and Program Start B for every major control change.

4. Area number, customer number and invoice number are printed for all cards.

5. Amounts are printed for all cards and at the same time accumulated in counter 4.

6. Counter 4 is wired to Read in plus in all card cycles.

7. In program step 1, counter 4 is read out and reset and counter 8 is read in.

8. The minor total is emitted from Counter Exit 4. At the same time, it is printed in print positions 28 - 32 and read into counter 8.

9. To differentiate the minor totals from the detail postings which are printed in the same print positions, an * sign is printed by print position 33 in the program.

10. Only one program step occurs in a minor program; if Program Start B is picked up, Program Stop is impulsed in the second program step.

11. In the second program step the major counter reads out and is reset.

12. The major total (area total) is printed by print positions 35 - 40 on the same line as the minor total.

13. Carriage wiring: a single space is taken after each card is printed by wiring AC to Carriage Start.

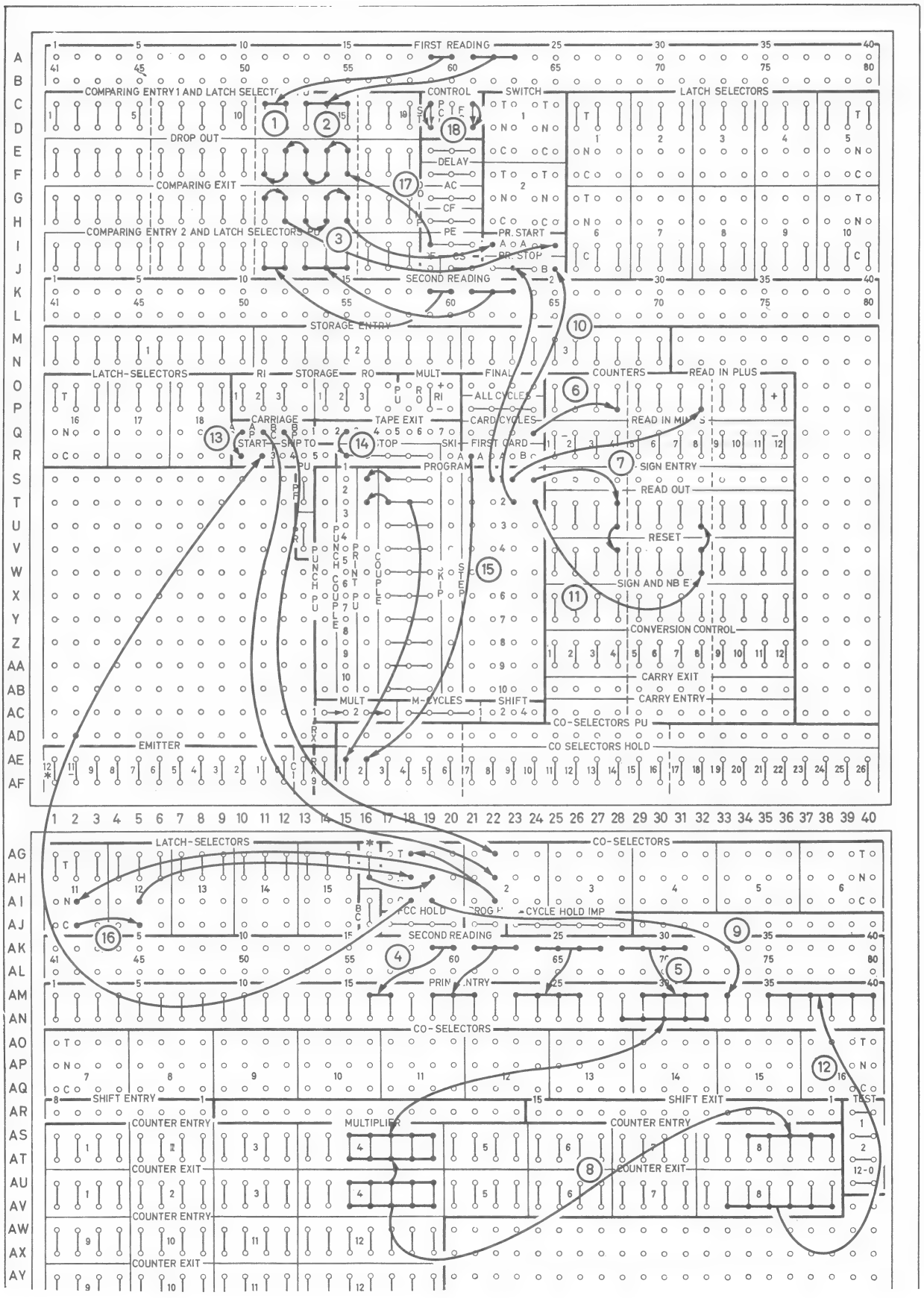
14. Because no carriage tape is employed, every carriage movement is ended after one space by this wiring. If the Carriage Start hubs receive two impulses (for example an AP and a BC impulse) between two print cycles (hammer trips), a double space will be taken.

15. Co-selector 2 is transferred for every first card after a program, so that the AC impulse passed through the Transferred and Common points of this selector and through the Normal and Common of latch selector 11 and 13 and co-selector 1 can cause an additional space. Thus there will be a double space between individual groups.

16. Latch selectors 11 and 12 and co-selectors 1 (and 2) operate so that the Carriage AP impulse reaches the Carriage Start hub only once during each program. Thus the major total and the minor total print on the same line and a space always takes place after the last program step. In a major program at least one of latch selectors 11 and 12 is transferred; co-selector 1 is transferred in the second program step.

17. After the last program cycle the latch selectors are dropped out.

18. Control ST is jackplugged so that the machine runs continuously when the Start key is depressed. The First Card switch is jackplugged so that the First Card hubs (R, 21-25) emit a cycle impulse in every first card cycle after a program.



Wiring No. 8 Group control and transfer of group totals.

Wiring No. 9

Group indication

Printing the indicative information of a group only once instead of on every line, as in normal list printing, is called group indication. To achieve this, the group indication is wired through co-selectors which are transferred only for the first card of a group.

This wiring is an extension to Wiring No. 8. The following illustration shows the same form layout as the illustration of Wiring No. 8 but with the difference that the major and minor group control numbers are printed only once each. Only the new control panel wiring, therefore, is described below:

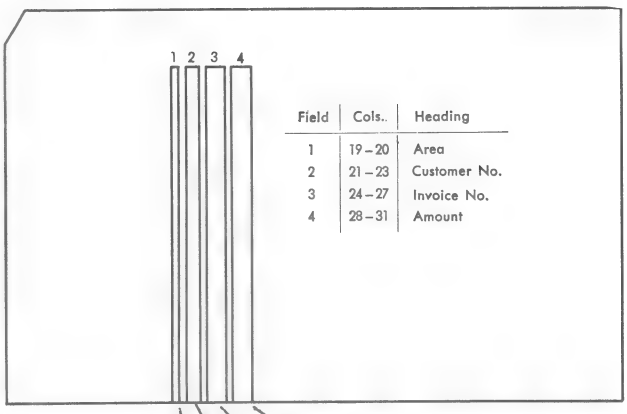
1. In every first card after a major or minor program, the First Card A hubs emit a cycle impulse to the Hold hub of co-selector 11.

2. Co-selector 11 is only transferred for the first card of a minor group. In this way the customer number is only printed the first time it occurs.

3. The First Card B hub emits, in every first card after a major program, a cycle impulse which is wired to the Hold hub of co-selector 10.

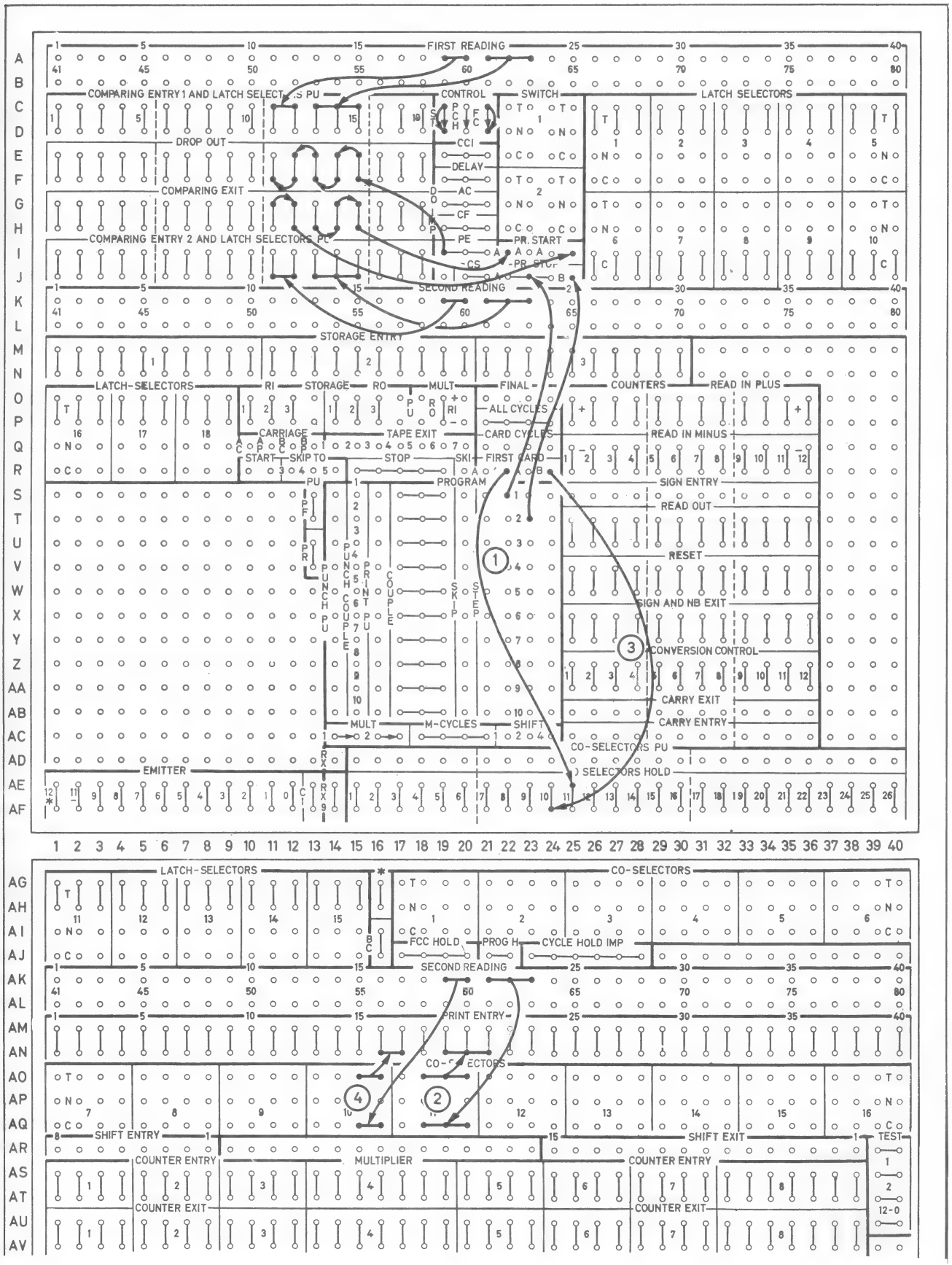
4. Co-selector 10 is transferred for the first card of a major group. Therefore the area number is printed only once.

If it should happen that only the major control number changes, if, for example, a card for area number 12, customer number 130, is followed by a card for area number 13, customer number 130, the customer number will again be printed since the First Card A hub emits after every program. This is correct, since the same customer number in this case refers to two different customers in different areas.



Field	Cols.	Heading
1	19–20	Area
2	21–23	Customer No.
3	24–27	Invoice No.
4	28–31	Amount

Area	Cust. No.	Inv. No.	Amount *= Cust. Total	Area Total
12	136	4573	3040	
		4678	2570	
		5622	720	
			6330*	
	137	4326	7220	
			7220*	13550
13	129	5637	4320	
		6272	3270	
		6273	5270	
			12860*	
	147	2772	415	
Print Positions:	16–17	19–21	23–26	28–33	35–40



Wiring No. 9 Group indication

Wiring No. 10

Multiplication A x B = C; Product punched into the same card

1. The multiplicand, which does not exceed 6 positions, is read from columns 12 - 17, printed in print positions 11 - 17 and read into counters 1 and 2.

2. These two counters are coupled.

3. The multiplier, of up to four positions, is read from columns 18-21, printed by print positions 19-22 and read into the multiplier counter (No. 4).

4. Counters 1, 2 and 4 read in the factors in every card cycle.

5. After each card has been read, Multiplication and Program Start A are picked up. Multiplication occurs between card cycle and program, so that the result of the multiplication can be printed in program step 1 and punched into the same card (which reaches the punch station during the multiplication). During the multiplication the following functions occur:

6. In every multiplication cycle (one machine cycle= 3 multiplication cycles) the Mult RO hubs emit an impulse which is wired to the Read Out hubs of the multiplicand counters (1 and 2).

7. In every multiplication cycle, the Counter Exit of counters 1 and 2 emit the multiplicand into the Shift Entry. The column shift unit consists of a multi-level-multi-position selector, so that the multiplicand, displaced column by column, is emitted from the Shift Exit hubs, producing the product by continued addition or subtraction into the product counter.

8. The Mult RO Plus and Minus hubs emit impulses during multiplication cycles for the read in plus or minus respectively of the product counters (here counters 7 and 8), depending on the digit in the appropriate multiplier position.

If the multiplier position contains a digit between 1 and 5, the Plus impulse is emitted for the number of cycles corresponding to the digit. At the same time, a 1 is subtracted from the appropriate multiplier position in every multiplication cycle; this process is repeated until the multiplier position contains 0.

If the multiplier position contains a digit between 6 and 9, the multiplicand is not added, instead it is subtracted the number of times corresponding to the 10's complement. To correct for this, 10 times the multiplicand is added to the product in the preceding cycle by means of a single addition of the multiplicand shifted one place to the left. At the same time, the 1 is added to the appropriate multiplier position and this process is continued until zero is reached. The carry is not passed on to the next position in this case.

If a multiplier position is 0, the position is skipped without loss of time. If the entire multiplier is 0, the multiplication is stopped after one cycle. At the end of a multiplication the multiplier counter stands at zero, so that it need not be reset.

9. Counters 7 and 8 are coupled together so that they can add and subtract.

10. Because the product may reach 10 positions, ten positions of the column shift exit are wired to the entries of counters 7 and 8.

11. In program step 1 the product counter is read out, all counters used are reset and program stop is impulsed.

12. Card Select is impulsed in every cycle; by this means every card is fed from the second reading station into the punch station.

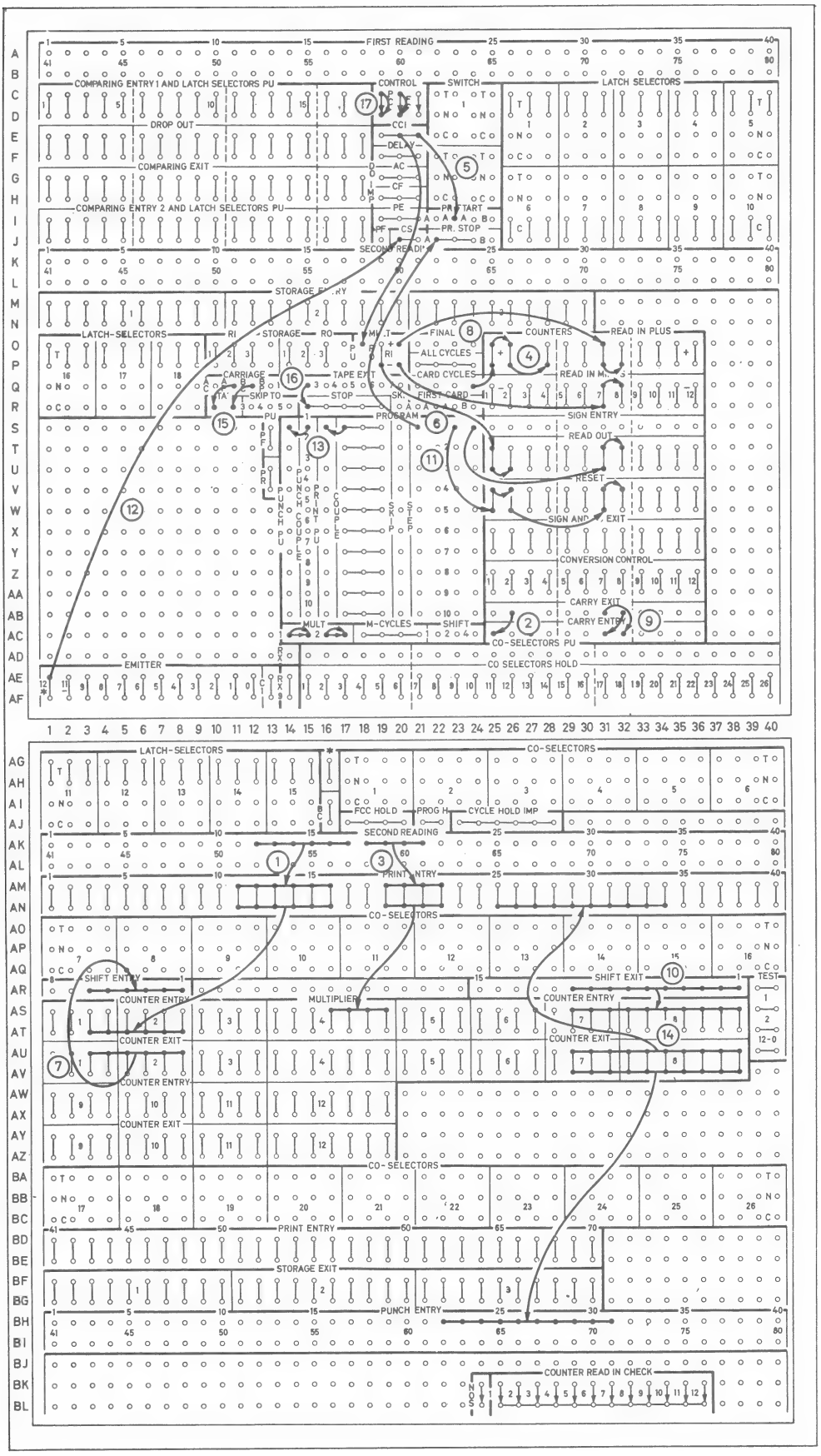
13. During multiplication the card is transported to the punch station and may be punched during the program step. At the same time the product is printed.

14. Counter Exits 7 and 8 are wired to Print Entries 24 - 34 and to Punch Entries 22 - 31.

15. The carriage is so wired that a single space before printing in card cycles and after printing in program cycles occurs. Thus the product C is printed on the same line as factors A and B with a double space between the print lines. If only a single space is required between print lines, then only the BC impulse need be wired to Carriage Start.

16. A carriage tape is not necessary if single spacing alone is required. Wiring any of the Tape Exit hubs to Carriage Stop causes the carriage to stop after a single space every time Carriage Start receives an impulse.

17. The Control ST and PCH switches are wired so that the machine can run automatically and cards can be punched. In addition, the Card Select key (No. 6) must be depressed.

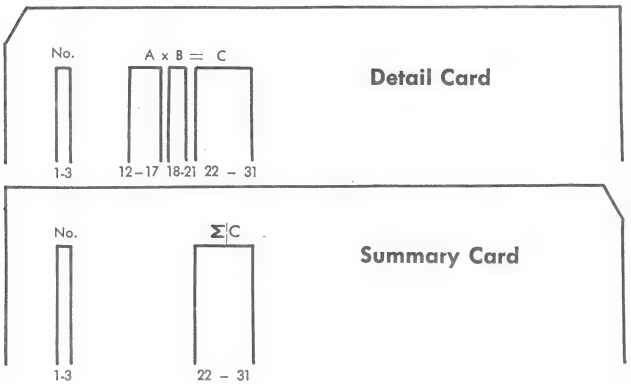


Wiring No. 10 Multiplication A x B = C; Product punched into the same card.

Wiring No. 11

(Extension to Wiring No. 10) - Combined extension and total punching

In Wiring No. 10 the machine operated as a calculating punch, whereby the product of two factors A and B was punched into the same card. This procedure is known as "extending" products. This wiring can be extended to include printing the sum of the products of a card group at the end of a group and punching this total into a summary card. This facility may be used, for example, in invoicing, to obtain extensions of quantity x unit price and to produce a summary card at the end. This wiring is only an extension to multiplication wiring (No. 10), so that all the wiring shown there is assumed to be present, although not described below:



No.	A×B		= C
101	1275	25	31875
	310	217	67270
	80075	4350	348326250
			348425395*
102	173	12	2076
	2020	38	76760
	949831	3513	3336756303
	1817	5811	10558587
			3347393726*
103	8700	312	2714400
	1937	112	216944
	20719	15	310785
	385	9	3465
	6200	120	744000
	325	4320	1404000
			5393594*
6 - 8	11 - 16	19 - 22	25 - 35

1. Columns 1 - 3 contain the control number and are wired for comparing.

2. Program Start B is impulsed on a change in control number, so that two program steps can take place. Multiplication occurs before the first program step; the product is printed and punched in this first program step (see Wiring No. 10).

3. Since more than four program impulses are required in program step 1 the second program impulse row is coupled, so that eight independent program impulses are available.

4. Counters 11 and 12 accumulate the product in every first program step.

5. The 12 impulse can be wired permanently to the CS (Card Select) hub if cards are to be punched from both the first and the second hoppers.

6. When a B program occurs, a summary card has to be punched in the second program step, therefore a card must be fed from the punch hopper in the first program step. For this, a Program Step impulse is wired into the contacts of latch selectors 1 to 3 so that it reaches the PF (Punch Feed) hub if any one or more of these selectors is transferred, which will be the case on any control change.

7. The Control FC (First Card) switch is jack-plugged to make the First Card hubs operative.

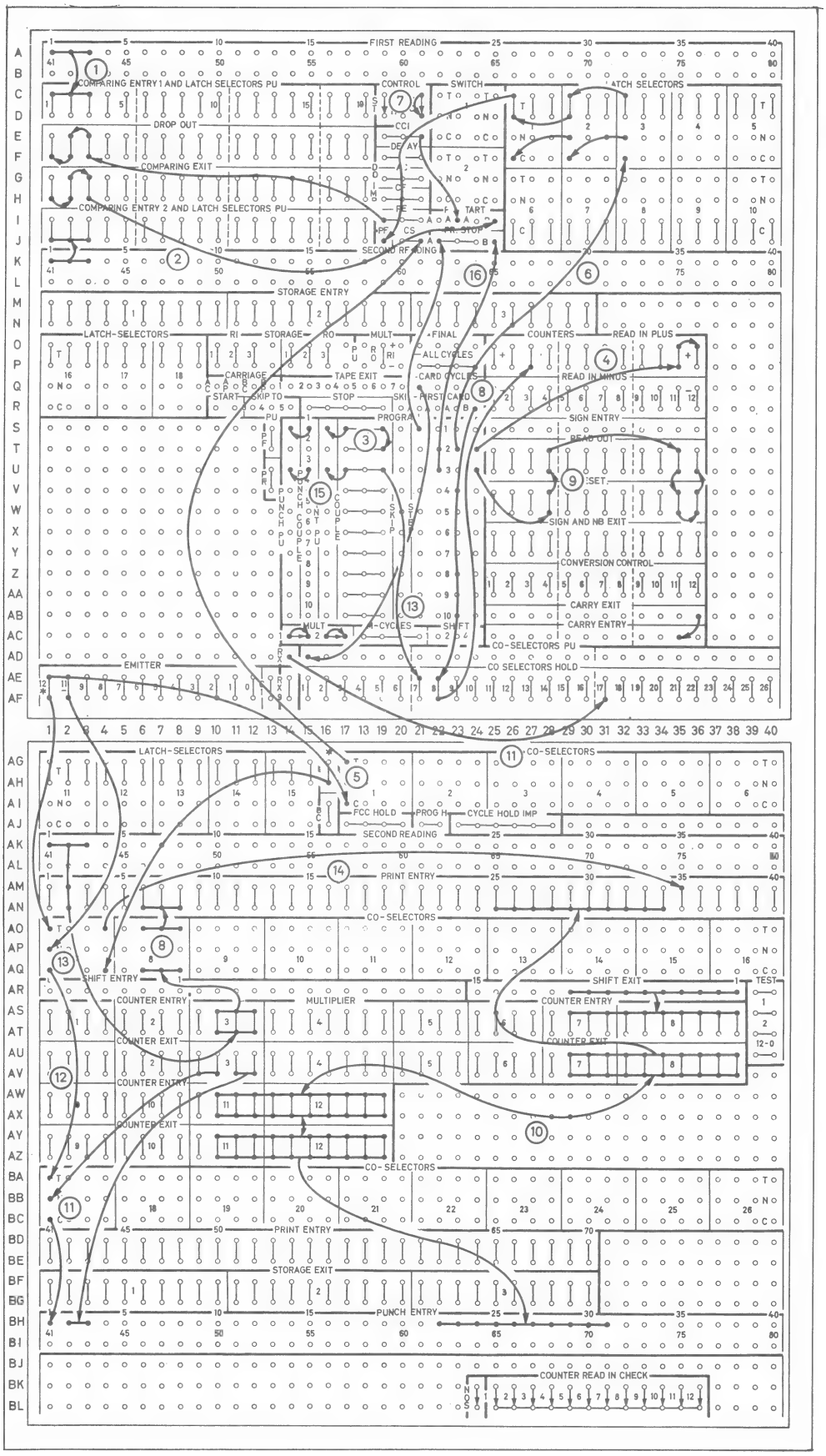
8. Counter 3 Read In Plus is impulsed on every first card of the group so that the group control number is entered into the Entry hubs of counter 3. At the same time, it is wired to Print Entries 6 - 8 through the Transferred side of co-selector 8 to print as group identification.

9. In the second program step, which only occurs on a control change, the total counters (11 and 12) emit the total for printing and punching and are reset. At the same time, counter 3 emits the group control number for punching and is reset.

10. Print Entries 25 - 34, Counter Exits 7 and 8, Counter Entries and Exits 11 and 12 and Punch Entries 22 - 31 are "channel-wired"; there are two exits and three entries in this chain. Channel-wiring is permitted provided no two or more exits emit at the same time. Here, counters 7 and 8 read out in program step 1 and counters 11 and 12 in program step 2. The results are printed and punched each time. Counter Entries 11 and 12 accept only in program step 1.

11. Co-selector 17 is used as a column-split. The group control number from Counter Exit 3 is wired to Punch Entries 1 - 3, the first position being taken through the Normal side of the column split to column 1.

12. Through the Transferred side of the column split, an identifying punch 11 (for detail cards) or 12 (for summary cards) is wired for punching over the first position of the group control number in column 1.



Wiring No. 11 (Extension to Wiring No. 10) - Combined extension and total punching

13. Co-selector 7 is transferred during the second program step and selects the identifying overpunch, which is to appear in all cards: an 11 for detail cards and a 12 for summary cards.

14. A 12 impulse from the * (Program Cycle Symbol) hub is wired through the Transferred side of the same selector to Print Entry 35, so that the total of the products is identified by a printed total symbol.

15. Print Pick-up and Punch Pick-up are wired so that the total will be printed and punched.

16. In the second program step, Program Stop B is impulsed.

Wiring No. 12

Multiplication ±A x B = ±C; Punching the product in the same card

The difference between this wiring and Wiring No. 10 lies in the fact that the multiplicand, and hence also the product, can be negative. Only the new control panel wiring is described here.

1. Co-selectors 1 and 25 operate as column splits. Two selectors are used here merely to make the wiring easier to follow.

2. The units position of the multiplicand is wired through the column split: the digit is wired to Print Entry 16 and to Counter Entry 2.

3. If the multiplicand is negative, the Transferred hub of co-selector 1 emits an 11 impulse which is wired to Print Entries 17 and 35. This prints, in card cycles, the minus sign for both multiplicand and product, because if the multiplicand is negative it follows that the product must also be negative.

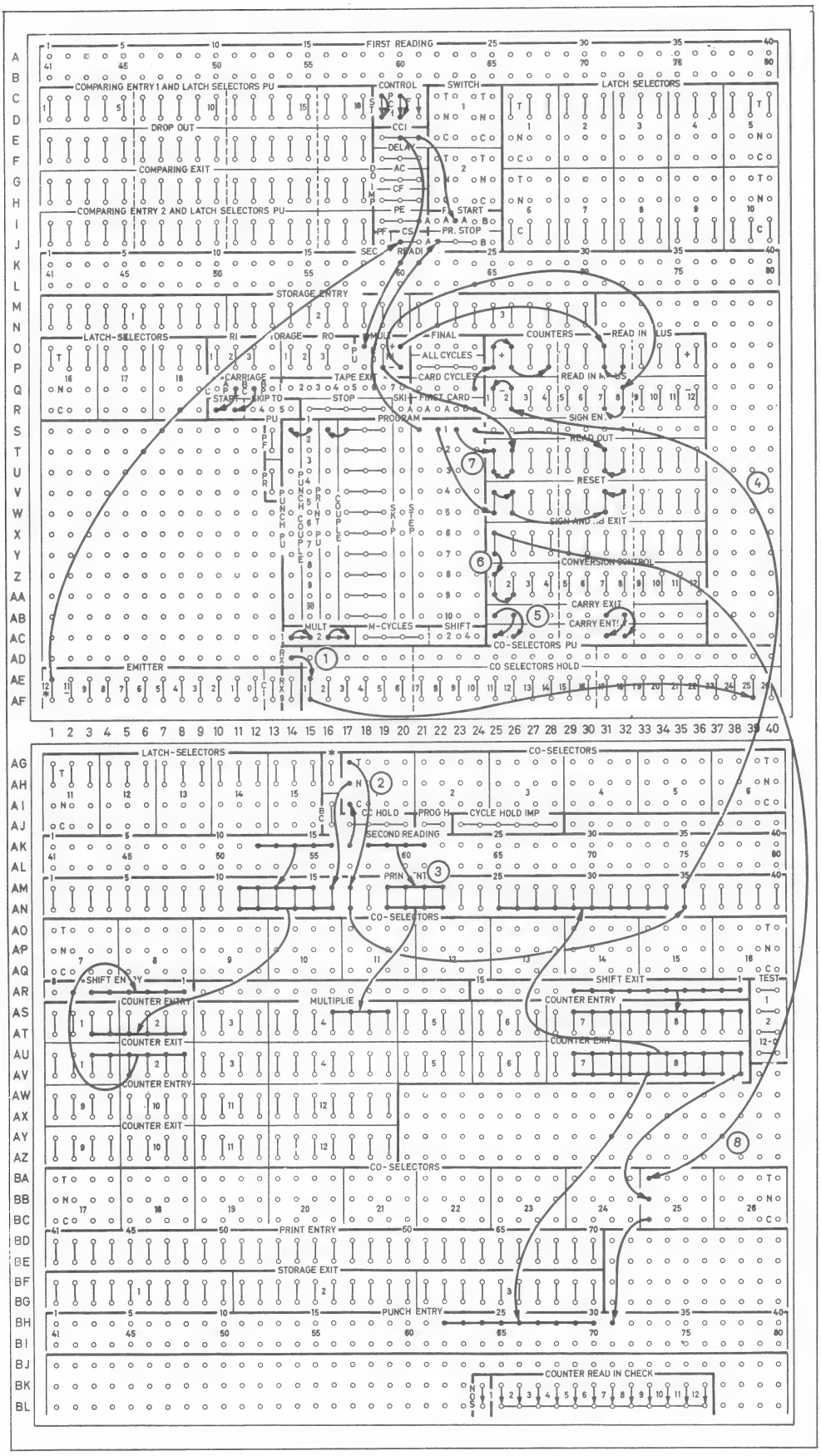
4. This 11 impulse is also wired to the Counter Read In Minus hubs of counters 1 and 2, so that a negative multiplicand will be entered into the counters as negative (in 9's complement form).

5. The Carry hubs are wired to permit subtraction to take place correctly.

6. When the multiplicand counters are read out during multiplication, the Sign and NB Exit hubs of counter 1 emit an impulse to Conversion Control in every multiplication cycle (= 1/3 machine cycle), so that the multiplication always operates on positive amounts.

7. So that a negative product can be overpunched with an X in the units position, the multiplicand counter is read out once more in program step 1. The negative sign of the multiplicand is thus stored, since the highest position of counter 1 contains a 9 (if the multiplicand in this case had been increased to 8 digits, a solution of the problem similar to Wiring No. 13 would have been advisable, since, as is well known, one counter position is lost for negative balance control).

8. The 11 impulse from the Sign and NB Exit hub of counter 1 is combined, in the column split (co-selector 25), with the units position of the product and is wired to Punch Entry 31.



Wiring No. 12 Multiplication $\pm$ A x B = $\pm$ C; Punching the product in the same card

Wiring No. 13

Multiplication ±A x ±B = ±C; Punching the product in the same card

This wiring is the further development of Wirings No. 10 and 12. In this, the multiplier, as well as the multiplicand, may be negative. The sign of the product is governed by the following rules:

The product is positive, when both factors have the same sign. The product is negative when the factors are of unlike sign.

1. The units position of the factors are wired through column split (co-selector 1). The minus signs are printed in the print positions to the right of the appropriate factors.

2. The sign impulses are wired to the pick up hubs of latch selectors 1 and 2, so that the signs are stored until the end of the program.

3. Both sign selectors are dropped out after the program.

4. The carry back does not have to be wired here, in contrast to Wiring No. 12, because the multiplicand is only entered into the counter as positive.

5. Co-selector 7 is transferred in program step 1.

6. The 11 impulse passes during the first program step through the transferred side of co-selector 7 to the points of latch selectors 11 and 12.

7. The Sign impulse only passes through the latch selectors 11 and 12 if one of them is transferred. If both are transferred or both are normal, the impulse does not get through. In this way the sign rules are obeyed.

8. For a negative product a minus sign is printed in print position 35.

9. The Sign impulse is combined, in a column split (co-selector 25), with the units position of the product and wired to Punch Entry 31.

Wiring No. 14

Multiplication A x B = C without program, using alternation of counters

This wiring operates in the same way as Wiring No. 10, but without a program. Thus one machine cycle is saved for every card. This increase in efficiency is obtained by using two groups of counters for the multiplicand and using them alternately.

Counter allocation:
Multiplicand: Counters 1, 2 and 5, 6 alternately
Multiplier: Counter 4
Product: Counters 7, 8.

Method of operation:
Counters 1 and 2 read in the multiplicand in uneven card cycles, read it out to the shift unit during the following multiplication and are reset in the following card cycle.

Counters 5 and 6 read in the multiplicand in even card cycles, read it out into the shift unit during the following multiplication and are reset in the following card cycle.

Counter 4 reads in the multiplier in all card cycles and is reset to zero at the end of the multiplication.

During the multiplication the product is developed in counters 7 and 8. In the following card cycles the product is read out for printing and punching. It should be noted that the printing of factors should be delayed by one card cycle if they are to appear on the same line as the product. This delay is achieved by introducing a storage unit, which always reads out, one card cycle later, what was read in, if Storage Read In and Read Out are simultaneously impulsed. The alternation is achieved by the use of latch selector 9 and co-selectors 1 and 2 (two co-selectors are used to simplify the appearance of the diagram).

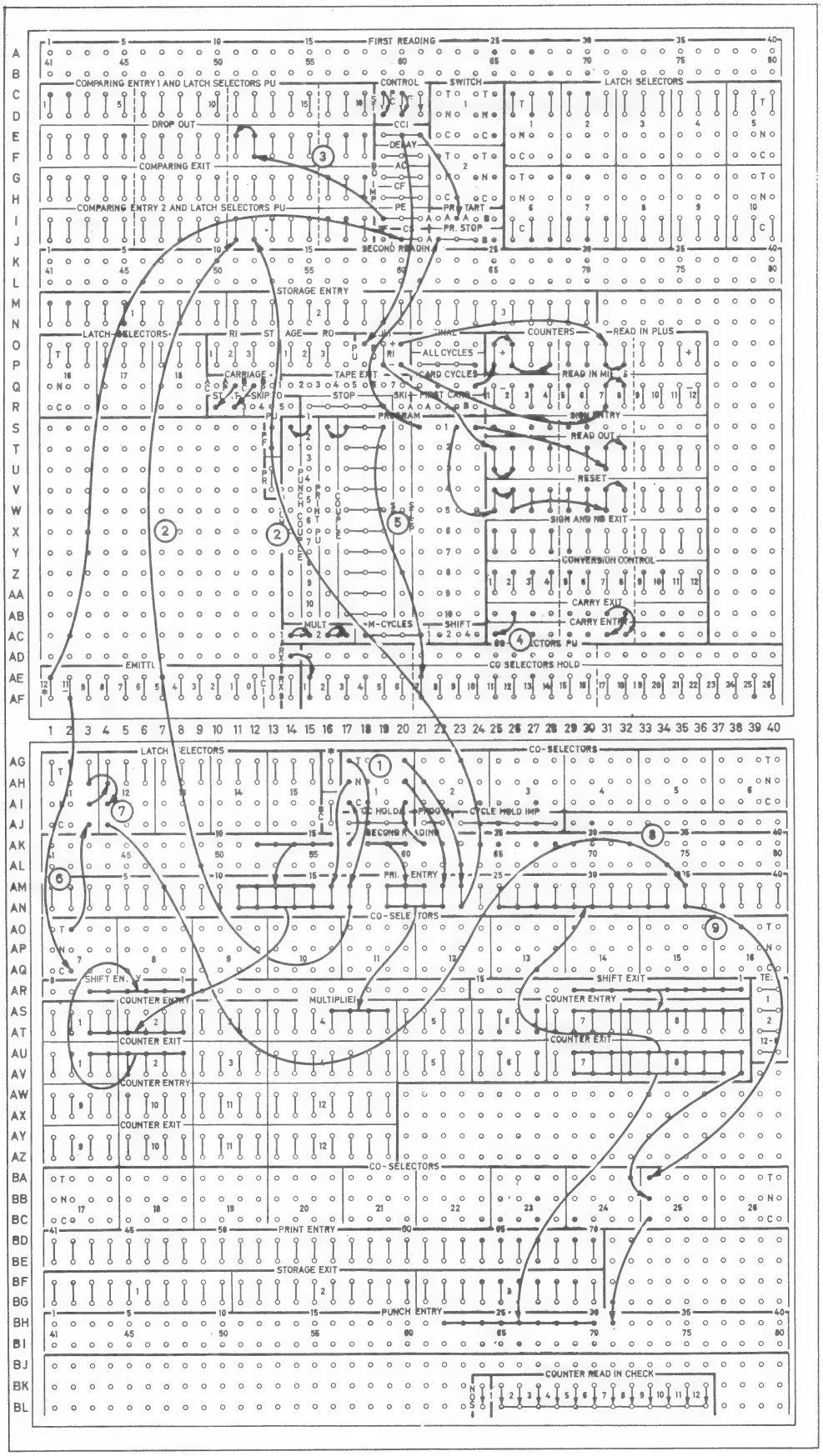
In the first card cycle co-selector 1 is normal. Therefore, through the normal of this selector, the A impulse from the CCI hub can reach the Pick-up of latch selector 9. Shortly afterwards, the Comparing Exit of latch selector 9 emits a B impulse to pick up co-selector 1. Co-selector 1 is transferred from the B pick-up impulse time until 240° of the next card cycle (also through any intervening multiplication). In the second card cycle the A impulse reaches the Drop Out hub of latch selector 9 through the Transferred side of co-selector 1, so that in this card cycle Comparing Exit 9 does not emit a B impulse. The following sequence diagram shows the operation of the selectors and the alternation of counters:

1. Multiplication is picked up in every card cycle.

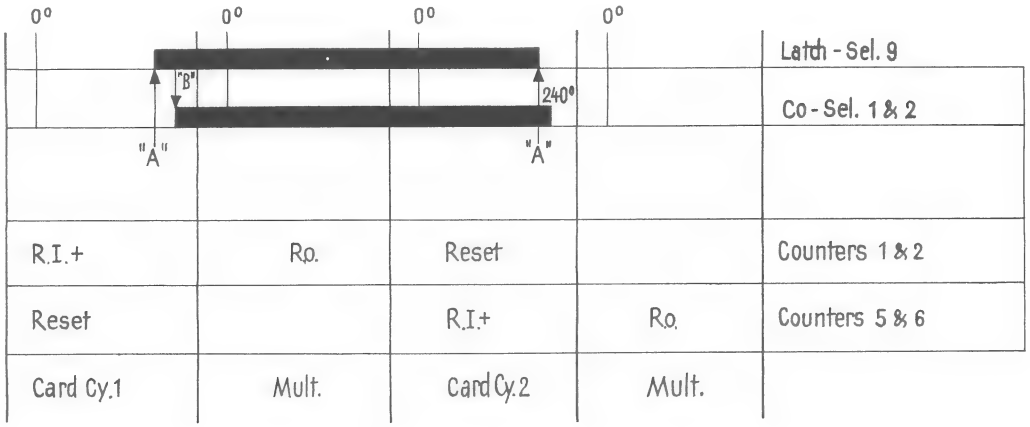
2. The multiplier counter accepts in every card cycle.

3. An A impulse from the CCI hub is wired to the Common hub of co-selector 1 and passes, in uneven card cycles, through the Common and Normal to pick up and, in even card cycles, through the common and transferred to drop out latch selector 9.

4. In uneven card cycles, latch selector 9 Comparing Exit emits a B impulse to pick up co-selector 1.



Wiring No. 13 Multiplication $\pm A \times \pm B = \pm C$; Punching the product in the same card



5. Co-selector 1 is held until 240° in the next card cycle by means of a FCC Hold impulse.

6. A card cycle impulse is wired through co-selector 2 so that in uneven card cycles (co-selector 2 normal) it resets counters 5 and 6 and reads in counters 1 and 2 and in even card cycles it resets counters 1 and 2 and reads in counters 5 and 6.

7. The Mult RO impulse is wired through co-selector 2, so that for multiplication after uneven card cycles counters 1 and 2 read out, and for multiplication after even card cycles counters 5 and 6 read out.

8. The entries and exits of counter groups 1, 2 and 5, 6 are channel-wired together.

9. The factors are read into storage 2 in every card cycle. Since Storage Read In and Storage Read Out are impulsed in every card cycle, the data which was read in is emitted from the storage in the following card cycle. By this means, a one card cycle delay is obtained.

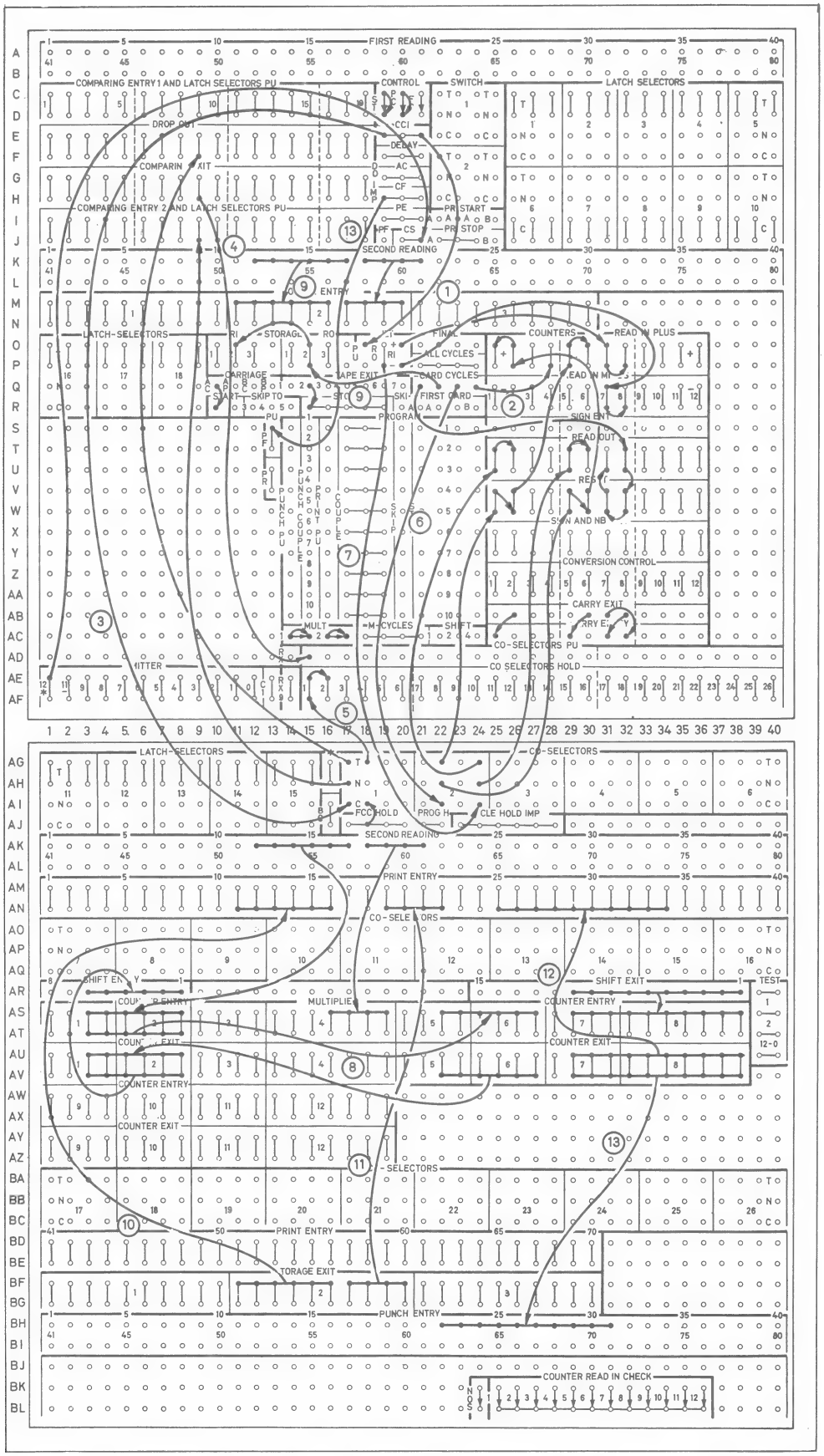
10. The multiplicand is printed in print positions 11 - 16,

11. the multiplier in print positions 19 - 22, and

12. the product in print positions 25 - 34, on the same line as the factors.

13. The product, at the same time as it is printed, is punched into the card from which the factors were read.

Note:
A blank card should be passed through the machine at the beginning of a run, to reset the storage. Similarly, a blank card must be placed at the end of the card deck, so that the factors and results of the last card are printed.



Wiring No. 14 Multiplication A x B = C without program, using alternation of counters

Wiring No. 15

Reproducing

Reproducing is the term used to describe a transfer of data from one deck of punched cards to another. The second deck will usually consist of blank cards.

The punched source cards are placed in the hopper of the reading unit and the blank cards in the hopper of the punch unit. For reproducing, the following keys must be depressed:

No. 3 Form Stop Suppress (since paper is not inserted)
No. 4 Switch 1 (only in this example; see below)
No. 7 Punch (SUM. P. REPR.) (so that cards can be fed from the punch hopper)
No. 9 Tabulate (so that the print unit will not operate unnecessarily).

In the following wiring, various types of reproducing are illustrated:

Field A: Straight reproducing, that is all punched data is to be reproduced.
Field B: Selective reproducing, that is certain fields only are to be reproduced from particular cards containing an identifying punch (the whole card can be dealt with in the same way if required).
Field C: Offset reproducing, that is the data is punched into columns other than those from which it was read.
Field D: Checked reproducing, which requires two runs. In the first run (reproducing) the data being punched is also added into counters. This total must agree with that obtained when the reproduced card deck is passed through the machine in a second (check) run.
Field selection is also possible, although not shown in this example (see Wiring No. 1).

Connections

1. Field A (columns 1 - 8) is reproduced into the same columns.

2. Field B is only reproduced for those cards with an identifying punch in column 80. For this reason, the connection from Second Reading columns 9 - 15 to Punch Entries 9 - 15 is wired through co-selectors 9 and 10.

3. The identifying punch is sensed at First Reading and is wired to pick up latch selector 12.

4. The B-impulse from Comparing Exit 12 picks up co-selector 8 (and 7),

5. which is held with a FCC Hold impulse so that it is transferred when the card to be reproduced is at Second Reading.

6. Field C (columns 21 - 28) is reproduced offset into columns 55 to 62.

7. The senior position of this field (column 21) contains an overpunch which does not have to be reproduced. It is therefore wired through the Normal side of co-selector 2, which is operating as a column split.

8. Field D (columns 37 - 40) is reproduced into the same columns. At the same time the accuracy of reproduction is to be checked. For this purpose, the field to be checked is wired via the double hubs of Counter Entry 7 and 8 and

9. these two counters are impulsed to read in in card cycles.

10. The carry between the two counters must be wired, since addition is to take place.

11. When merely reproducing, the two hubs of the Control PCH switch can be connected directly together. In this example, this connection is taken through the Transferred side of alteration switch 1 so that, in the second run, in which only the read unit is used, the punch magnets will not be impulsed unnecessarily. The procedure is therefore: for the first run (reproducing), keys 4 (Switch 1) and 7 (Punch) must be depressed, for the second run (checking) they must not be depressed.

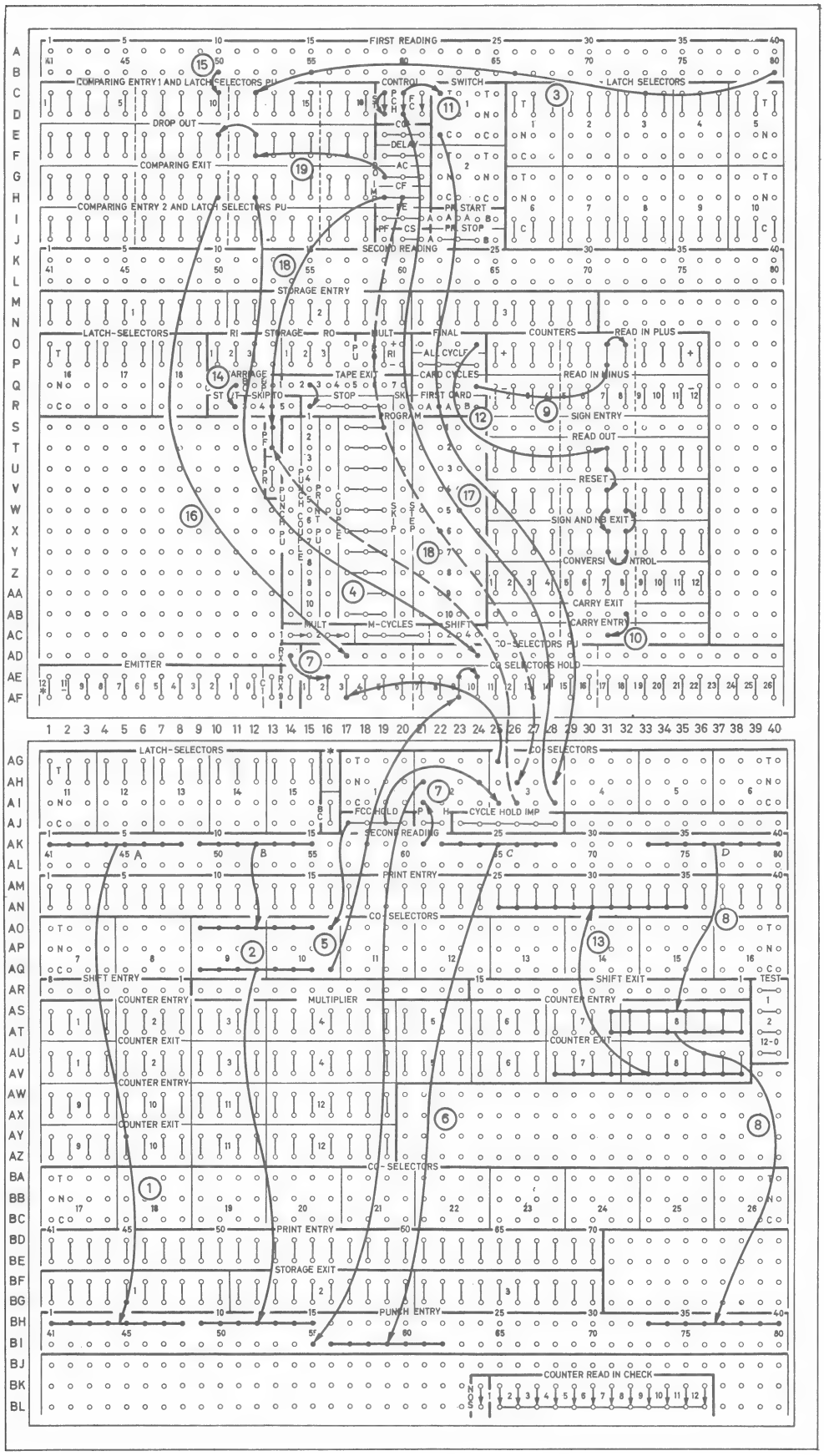
12. The Final key must be depressed before beginning the operation, so that the counters to be used are reset. After each of the two runs, the key must again be depressed, so that the check total will be printed out.

13. The counters used must have two or three positions more than the number of columns in the field to be checked. Counter Exit can be wired to any desired print entries.

14. The Carriage AP hub emits a C impulse in final cycles also, so that spacing can occur after printing the checked total. For this a paper tape is not necessary. However, Carriage Stop must be wired.

15. If, in selective reproducing, the entire card has to pass unpunched through the punch station, no further selectors (as in connection 2) are required for punch suppression because the connection between the two hubs of the Control PCH switch can be selected.

In this example, cards which are not to be punched contain an identifying punch in column 50.



Wiring No. 15 Reproducing

16. A cycle delay is obtained in the usual manner: co-selector 3 is transferred if the card at the Second Reading station does not have to be reproduced.

17. In this case the connection between the two hubs of the Control PCH switch is interrupted, so that the blank card is passed through the punch station without punching.

18. For reproducing, this connection between CF and PF PU is wired direct. If, however, in selective reproducing, no card is to be fed (and punched) in the punch unit, then this connection can also be selected through co-selector 3 (dotted wiring).

19. Latch selectors 10 and 12 are dropped out in every working cycle.

Note:
If selective reproducing has to be combined with checking, connection 9 must be wired through the appropriate co-selector so that only amounts in the reproduced cards are added.

Wiring No. 16

Interspersed master card gang punching from counters and storage

For interspersed master card gang punching, the information to be punched is read from the master card at Second Reading into a counter or, for alphabetic information, into storage. In subsequent cycles, this information is read out of the counters and storage and punched into the following detail cards.

The above sequence diagram brings out the following points:

1. The master card also passes through the punch station, therefore punching must be suppressed when a master card is passing through the punch station.

2. The last detail card of a group must first be punched before the following master card is read at Second Reading.

3. The counters must be reset when the last detail card is punched so that, in the next card cycle, data from the following master card can be read in (storages need not be reset).

Following on from point 1: If the cycle in which a master card is read is called cycle 1, then in every case the master card passes through the punch station in the third cycle of the operation. This third cycle is normally a card cycle; if, however, a further master card follows immediately behind a master card or there is only one detail card between them, then the third cycle is a program cycle. The necessary delay must therefore be independent of whether a card cycle or a program cycle is concerned.

Following on from point 2: The necessary delay between the individual card groups will be obtained since a program of two steps will always be initiated when there is a master card at First Reading. During these two program cycles the last detail card of the preceding group passes through the card select station and the punch station.

Following on from point 3: The counters can always be reset in the second program step.

The following points concern the control of individual functions:

Program Start:
As soon as a master card passes First Reading, Program Start is impulsed. During the ensuing program cycles, this master card remains before the second reading station. The card ahead of it is moved on during this program and, if it is a detail card, is punched.

	CC	Program		Card Cycles					Program		Card Cycles		
1. Reading													
2. Reading													
Card Select													
Punch Station													
Prog. Start	x							x					
Read In +				x							x		
Read Out	x	x	x		(x)		x	x	x	x		(x)	
Reset			x							x			

Counter and Storage Read In:
The counters and storage read in in every first card cycle after a program. If only numerical information is to be punched, Counter Read In can be controlled by the X in the master card read from Second Reading. If storages are also to be used, Storage Read In must be controlled by a cycle impulse (card cycle or program cycle impulse, not however, All Cycles). This cycle impulse must be selected through a latch selector picked up by a D impulse from the PE hub.

Counter and Storage Read Out:
Although there can never be a card at the punch station in the first cycle, Counter Read Out must not be impulsed because in this cycle the counter has to read in. Likewise, there is no card at the punch station in the second cycle; here Counter Read Out need not be suppressed.

Control panel wiring:

1. Program Start is picked up when an X from a master card is sensed at First Reading.

2. Latch selector 10 is picked up at the beginning of the first card cycle by a D impulse from the PE hub, so that in the first card cycle a cycle impulse can be selected. Normally, to obtain a cycle delay in the next card cycle, co-selectors held by means of an F CC Hold impulse are used. This is not possible here, however, because both card cycles and program cycles are concerned. There is a further consideration in that idle cycles may intervene between working cycles, for example, if the machine is stopped. In this case the cycle progression must be stopped during idle cycles.
   To achieve this two-working-cycle delay, the four latch selectors 6-9 and co-selector 1 are needed. The following sequence diagram shows when the individual selectors are transferred and by which impulses they are picked up and dropped out. Afterwards the individual wiring connections are described.

3. Co-selector 3 is picked up by an All Cycles impulse and is transferred during all card cycles and program cycles.

4. Latch selector 6 is picked up in the first card cycle after a program by an X in column 80 from Second Reading.

5. Latch selector 6 is dropped out in the next working cycle by a 12 impulse from the emitter. This impulse passes, in card cycles and program cycles only, through the Transferred side of co-selector 1. Latch selector 8 is dropped out in the same way.

6. The AC Drop Out hub emits a D impulse in card cycles or program cycles only. This impulse passes through the Transferred side of latch selector 8 to pick up latch selector 7.

7. Latch selectors 7, 9 and 10 are dropped out by a D impulse.

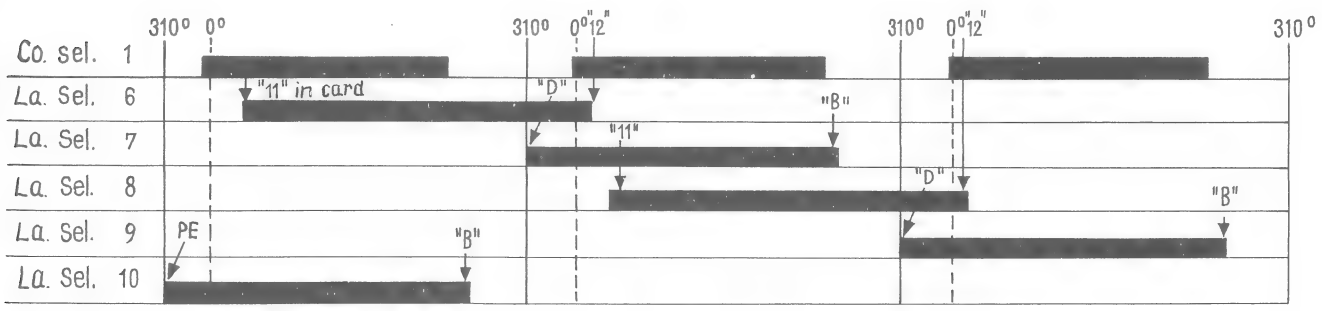
8. Latch selector 7 is transferred if there was a master card at Second Reading in the preceding card cycle. Through the Transferred side of this selector an 11 impulse from the emitter reaches latch selector 8 pick up. Latch selectors 8 and 9 are wired in the same way as latch selectors 6 and 7 and effect the second delay cycle.

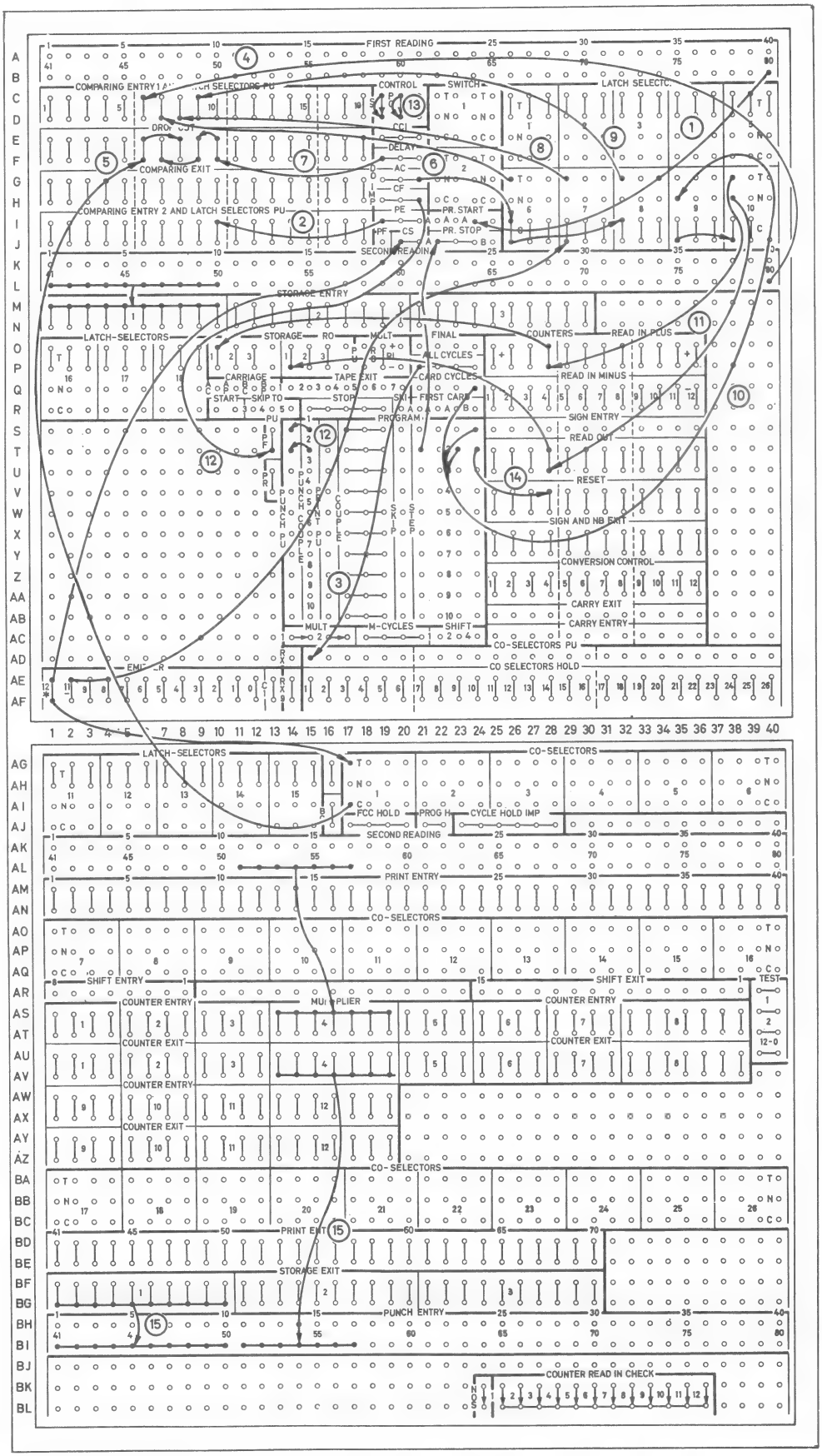
9. When latch selector 8 is transferred, a D impulse reaches latch selector 9 Pick-up. This selector is always transferred when a master card is passing through the punch station.

10. If cards are to be punched, Storage Read Out and Counter Read Out must be impulsed. Because an All Cycles impulse must not be used for storage control, in this example a suitable impulse, splitwired from the Card Cycles hub and Program Step exits 1 and 2, is passed through the Normal side of latch selectors 9 and 10. This connection is broken when a master card passes through the punch station (= latch selector 9 transferred).

11. Latch selector 10 is always transferred when a master card is at Second Reading. In this way, a cycle impulse reaches the Counter Read In and Storage Read In hubs.

12. Punch Pick-up is wired in card cycles and in program cycles so that all cards reaching the punch station are moved on (and punched).





Wiring No. 16 Interspersed master card gang punching from counters and storage.

13. Punch suppression is achieved here by preventing storage and counter read out. This could also been done by wiring the Control PCH switch through latch selector 9. The combined card cycle and program step impulse would then be wired directly through the Normal hub of latch selector 10. The Control FC switch must not be jackplugged because otherwise every first card cycle after a program would be a print cycle.

14. In the second program cycle, the counter is reset so that the next card can be read in. If additional counters have been used, the Carry hubs need not be wired since no addition is to take place, the amount being read in only once.

15. The same columns of Punch Entry are wired from Storage and Counter Exits as those from which the data was read at Second Reading. They could have been wired into other columns and this would then have been offset gang punching. The Card Select key (No. 6) must be depressed in this application.

Wiring No. 17

Interspersed master card gang punching from storage

If interspersed master card gang punching is done using storages alone, the wiring is greately simplified. Also, one cycle is saved for every master card, as the following diagram shows.

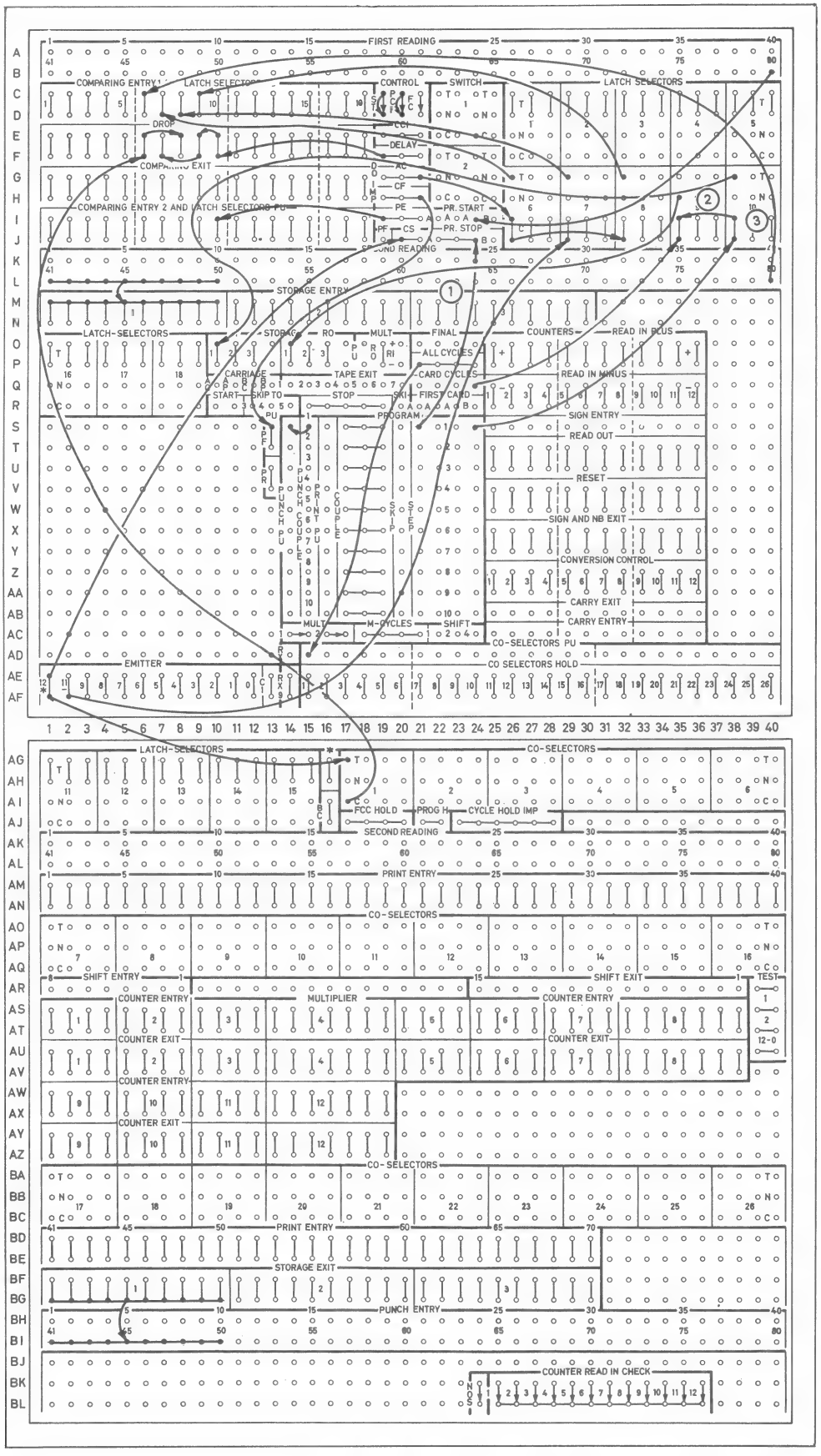
Because storages can read in new data and read out the old data in the same cycle, only one program step is needed. Apart from this, this wiring is very similar to the preceding. Only the altered connections are therefore described.

1. Only one program step is needed.

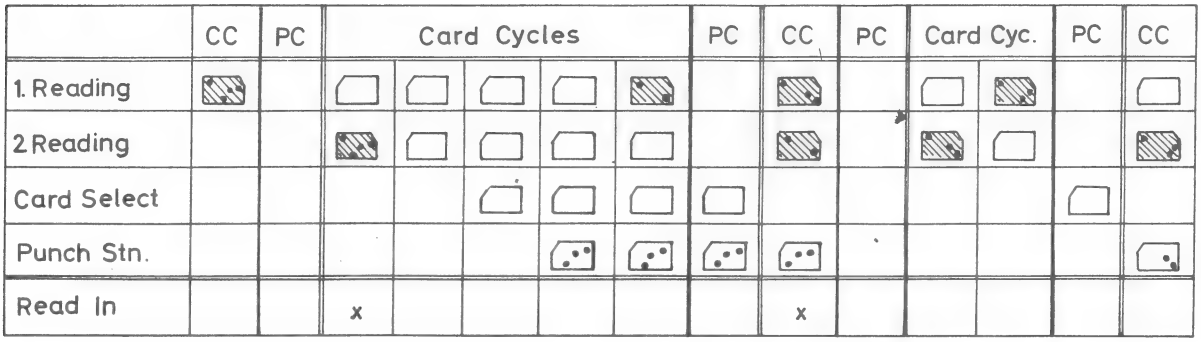
2. Latch selector 9 is always transferred for two working cycles after a master card was sensed and suppresses storage read out in the cycle in which the master card is moved through the punch station.

3. Latch selector 10 is transferred when a master card is sensed and controls storage read in.

	CC	PC	Card Cycles					PC	CC	PC	Card Cyc.		PC	Card Cyc.	
1. Reading															
2. Reading															
Card Select															
Punch Stn.															
Prog. Start	x						x		x			x			
Read In			x						x		x			x	
Read Out	x	x	x	x		x	x	x	x	x		x		x	x



Wiring No. 17 Interspersed master card gang punching from storage.



Wiring No. 18

Interspersed master card gang punching from storage with selection of master cards

For this application Wiring No. 17 is modified so that master cards are separated from the detail cards and stacked in stacker 1. The sequence diagram is similar.

Because the master cards do not have to pass through the punch station, there is no need for a double cycle delay. Only one latch selector is needed to select master cards and to control storage read in.

1. A combined cycle impulse (Card Cycle + first Program Step) is wired to Storage Read Out so that the storage reads out in every cycle (even when there is no card at the punch station).

2. Latch selector 18 is transferred during card cycles and controls storage read in. In the first card cycle of a group, the new information to be punched is read in from the master card and, at the same time, the detail card of the preceding group is punched with the old data.

3. All cards, except the first card after a program, are selected. In other words: master cards drop into stacker 1, detail cards are punched and drop into stacker 2.

Wiring No. 19

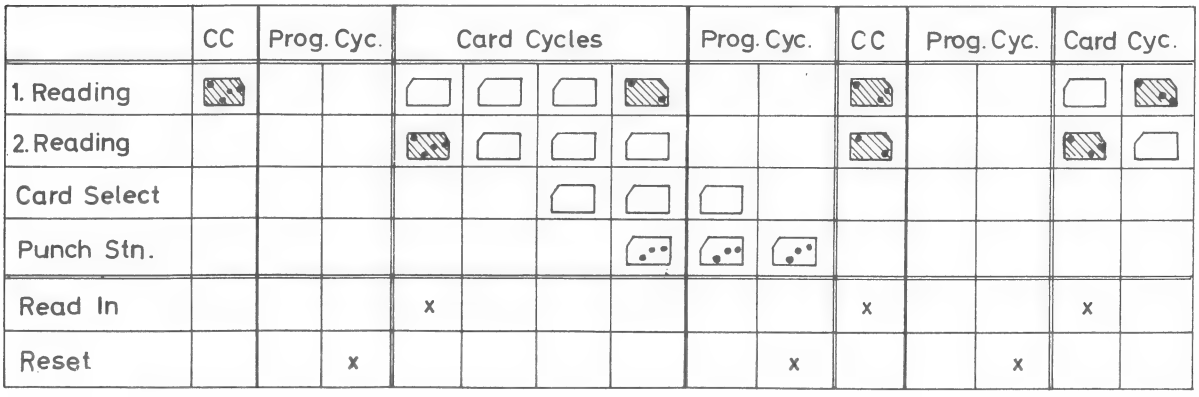
Interspersed master card gang punching from storage and counters with selection of master cards

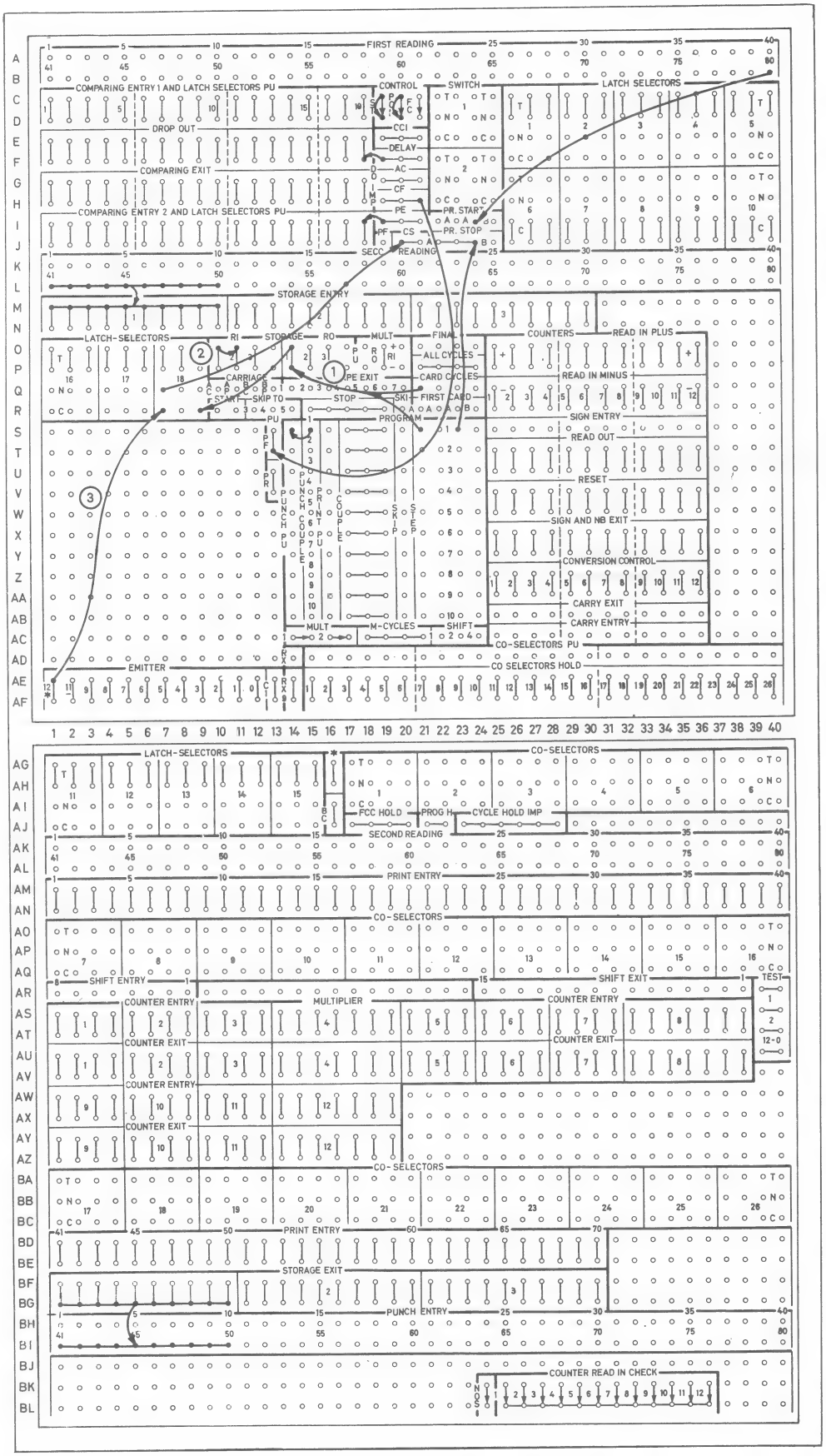
This wiring differs from the preceding one in that counters are also used. The cycle sequence is shown in the accompanying diagram.

Because counters, unlike storage, cannot read in and read out in the same cycle and also must be reset (with the last read out) before they are read in, two program steps are needed here:

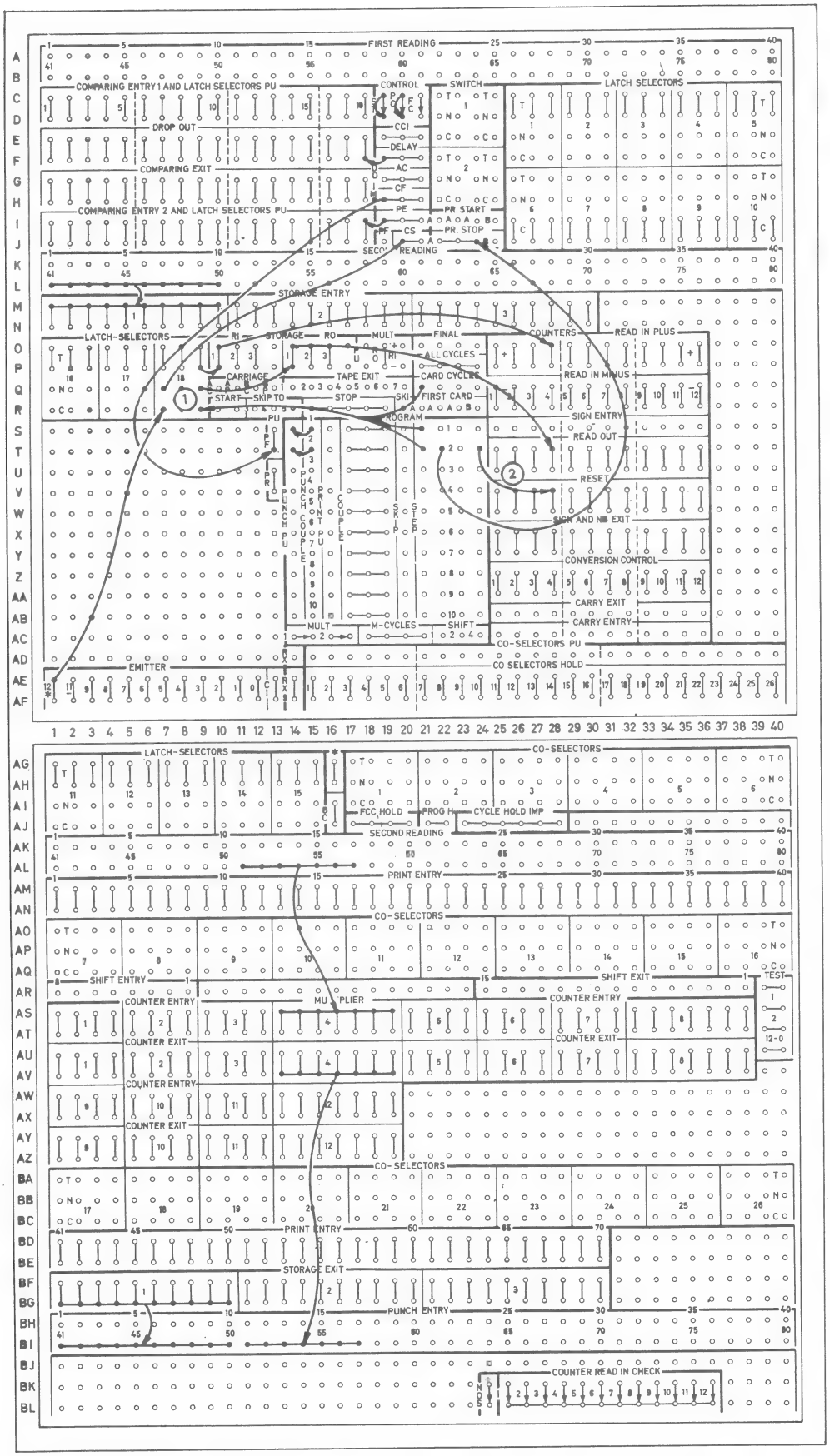
1. Latch selector 18 is transferred in the first card cycle after a program and controls storage and counter read in. In all other cycles the storage and counters read out.

2. In the second program cycle the counters are reset.





Wiring No. 18 Interspersed master card gang punching from storage with selection of master cards



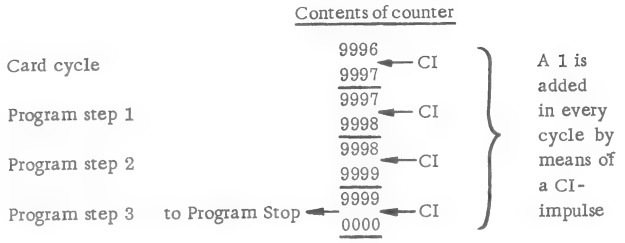
Wiring No. 19

Interspersed master card gang punching from storage and counters with selection of master cards

Wiring No. 20

Counter controlled gang punching from storage - without merging

In counter controlled gang punching, a number of detail cards, determined by a number punched into the master card, are to be punched from a master card. By this wiring, master cards pass into stacker 1 and detail cards into stacker 2. Wiring for this is quite simple but, in practice, separation of the detail card packs is quite difficult, where, for example, tub files are to be replaced by this method.



If all counter positions stand at 9, the CI-impulse is available from the Carry Exit hub.

1. Counter 1 reads in, from columns 1 to 4 of each master card, the number of detail cards which are to be punched.

2. This number is read into the counter, negative.

3. The master card contains any desired identifying punch, in column 80, which is wired to Program Start so that a program commences after every master card (except those with 0000 in columns 1 - 4).

4. The B impulse is wired to Program Skip 9, so that a repetitive program cycle occurs until Program Stop is impulsed.

5. Co-selector 1 is transferred during all card cycles and program cycles.

6. A CI impulse reaches the Carry Entry of counter 1 through the Transferred side of co-selector 1. Thus the counter is increased by 1 in every working cycle. In the cycle in which the counter stands at 9999, the CI impulse passes through all positions of the counter and is available from the Carry Exit hub. As an example to illustrate the counter operation, suppose columns 1 - 4 are punched with 0003: this figure will be read in, in complement form, during digit time.

There are therefore 3 program steps. At the end of the last program step, counter 1 stands at 0000, so that it does not need to be reset.

7. Program stop is impulsed with a CI impulse when counter 1 again stands at 0. For a master card which is punched with 0000 in columns 1-4 (or is unpunched), the counter stands at 9999 after read in so that the CI impulse passes, in the card cycle, through the counter to Program Stop. By this means, the program is suppressed and the counter again stands at 0000, ready for the figure to be read in from the next master card.

8. In every program cycle a card is fed from the punch hopper and is punched.

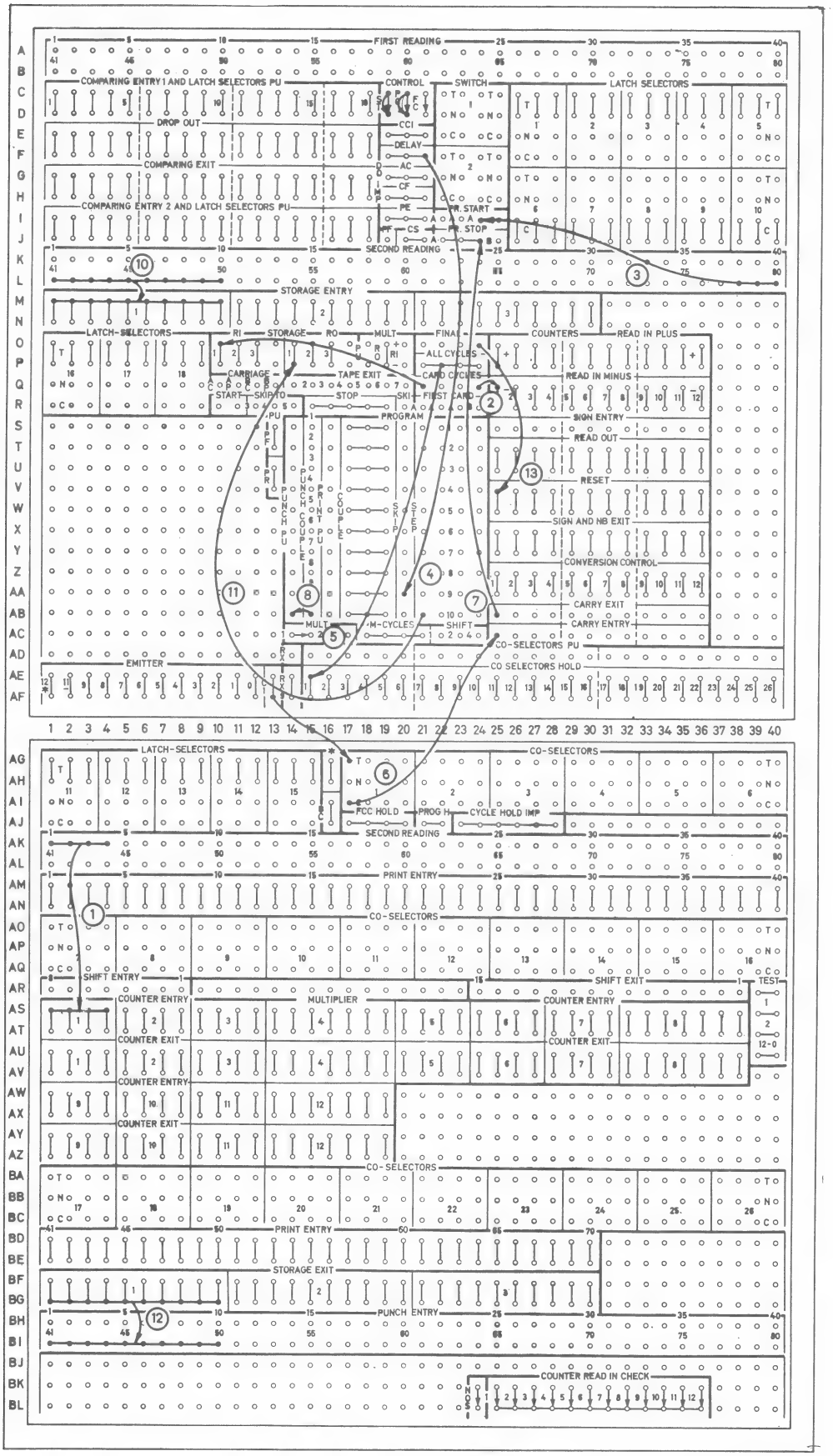
9. The storage reads in, in every card cycle.

10. The information to be punched is read into Counter Entry from Second Reading.

11. Storage is read out in every program cycle.

12. Storage Exit is wired to Punch Entry.

13. Before beginning a run, counter 1 must be reset by pressing the Final key.



Wiring No. 20 Counter controlled gang punching from storage - without merging

Wiring No. 21

Counter controlled gang punching from counters without merging

This application differs from the preceding in that the counters containing the data to be punched must be reset in the last program cycle. In the penultimate program cycle, after the CI impulse, the counter stands at 9999. The counter can be checked at this time by means of the B impulse from the Delay hub, without a 1 being added. When this impulse becomes available from the Carry Exit hub, it can be used to pick up a co-selector, which will be transferred in the next (= last) program cycle and can control counter reset. Only the altered control panel wiring is described below:

1. Co-selector 1 is transferred during all card and program cycles from 7 - 237°. It is therefore transferred during carry time (= A impulse) and normal in B impulse time.

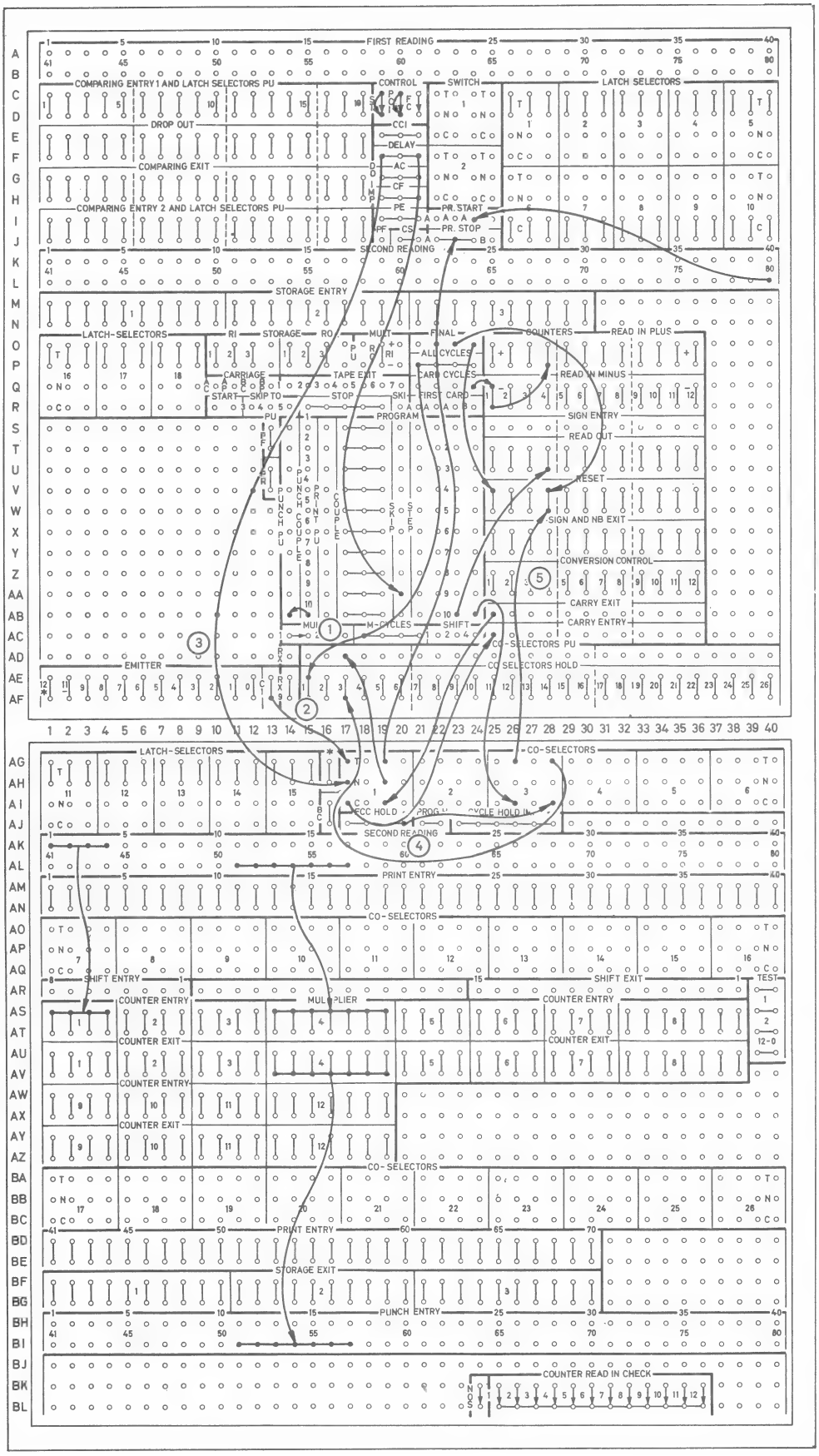
2. The carry impulse passes (as in Wiring No. 17) through the Transferred side of co-selector 1 to Carry Entry and from Carry Exit, when all counter positions are at 9, again through the Transferred side of co-selector 1 to Program Stop.

3. The B impulse passes through the Normal side of co-selector 1 to Carry Entry and from Carry Exit, if the preceding CI set all counter positions to 9 at the end of the cycle, again through the Normal side of co-selector 1 to pick up co-selector 3.

4. Co-selector 3 is held through one of its own Transferred points until 240° of the next card cycle. It is therefore transferred in the next (last) program cycle.

5. Co-selector 3 is transferred in the last program cycle, so that a Program Step impulse through the Transferred side can reset the counter.

It is ovious that the same wiring can be employed when punching from both counters and storages.

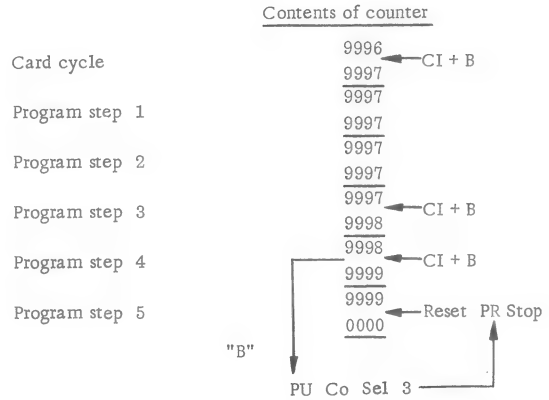


Wiring No. 21 Counter controlled gang punching from counters without merging

Wiring No. 22

Counter controlled gang punching from storages and counters with merging

For counter controlled gang punching with merging of master cards and detail cards, the master cards, after they have been read, have to be transported through the punch station (without punching), before punching of detail cards can begin. This takes two program steps. The following diagram shows the sequence of cycles:



NB. No connection between Carry Entry and Carry Exit in reset cycles.

In contrast to the two preceding wirings, master cards must not be punched with 0000 in columns 1 - 4 , otherwise 10,000 cards will be punched.

1. If master cards are punched with R (12) in column 80, this 12 impulse may be taken via the CS (Card Select) hubs to Program Start A. A program thus occurs after every master card and the master cards are directed to stacker 2.

   If the master cards contain any other identifying punch, the CS hubs must be wired with a 12 impulse from the emitter wired through a selector transferred only for card cycles. Then column 80 may only be wired to Program Start A.

2. The most important difference between this and the two preceding wirings is that two program steps (Program Step rows 8 and 9), in which the master card is transported through the card select station and the punch station, have to occur before the repetitive program step (Program Step row 10).

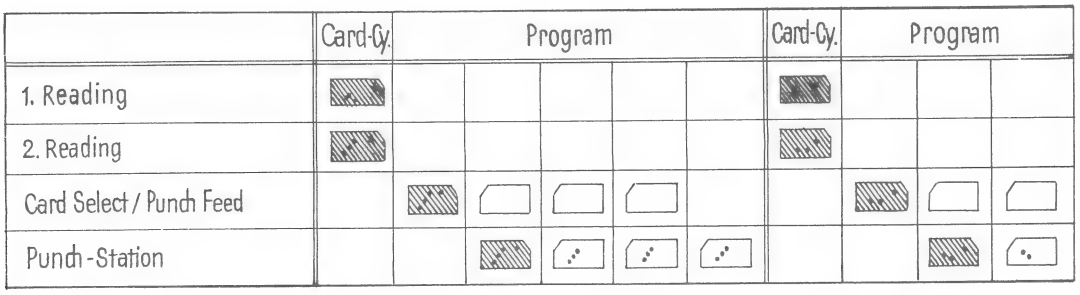
3. In the second program step, the first card is fed from the punch hopper, so that it is at the punch station in the next program step and can then be punched.

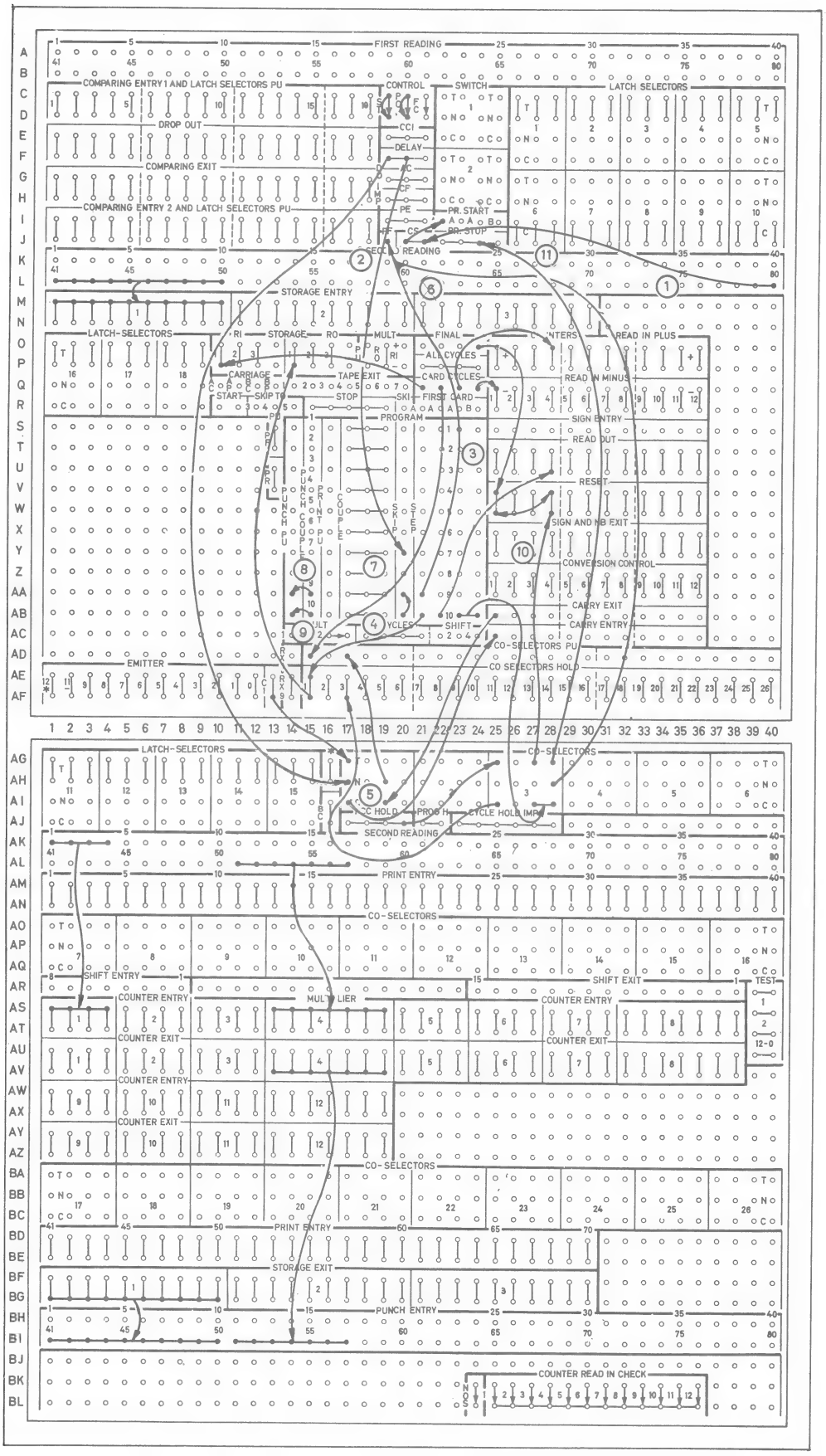
4. Co-selector 1 is transferred only in card cycles and during the repetitive program step, so that during the first two program steps the control counter does not change.

5. Co-selector 1 is wired essentially the same as in Wiring No. 21. It is transferred only during Card Cycles and the repetitive program step. In the penultimate program step the D impulse passes through two normal contacts of the selector and through the 9's contacts of counter 1 (Carry Entry to Carry Exit), to pick up co-selector 3. Program Stop is impulsed by a Program Steps Exit impulse selected through co-selector 3; it could equally well have been impulsed with a Carry impulse, as in the two preceding wirings. Then it would not have been necessary to have wired counter 1 Reset in the program.

6. Co-selector 3 is transferred only in the last program cycle, so that in the preceding repetitive cycle a program step exit impulse can reach the PF (Punch Feed) hub through the Normal side of this selector. In the last program cycle, no more cards are to be fed, because the card about to be punched was fed in the penultimate cycle and, following this, the card bed must be clear for the next master card.

7. The first program step (Program Step row 8) is idle. This cycle is needed only to allow the master card to pass through the card select station. The connection between Punch Couple and Punch Pick-up need not be wired in this step, because the punch drive is automatically coupled when the Card Select key is depressed and there is no card about to enter the punch station.





Wiring No. 22 Counter controlled gang punching from storages and counters with merging.

8. By means of this connection, the master card is transported through the punch station. Punching does not occur because there is no storage or counter read out.

9. This connection causes detail cards to be transported through the punch station during the repetitive program step.

10. Co-selector 3 is transferred in the last program step so that counter 1 (control counter) and counter 4 are reset.

11. Program Stop is wired at the same time.

Wiring No. 23

Counter controlled gang punching with serial numbering

For this application, Wiring No. 21 is extended to include punching of detail cards with a serial number in either ascending or descending sequence. For this, the numbering can begin or end with 1 or 0. If a 3, from the master card, is read in (negative) to control counter 1 or counter 6, three detail cards will be punched. Counter 1 emits the numbers 2, 1, 0; counter 5 the numbers 1, 2, 3 and counter 6 the numbers 3, 2, 1. Below is described the method of operation of the three different numbering counters, on the basis of this example:

1. Counter 1 reads in the digit 3, in card cycles, in complementary form, so that, at the end of digit time in the card cycle, the counter stands at 9996.

2. A 1 is added in every working cycle by means of a CI impulse.

3. In all program cycles (repetitive) the counter reads out, in true form because conversion control is also wired, the amount which it contained in the first part of the cycle.

	Contents of counter	Counter Exit
Card cycle	9996 ← CI 9997	
Program step 1	9997 ← CI 9998	0002
Program step 2	9998 ← CI 9999	0001
Program step 3 to Program Stop	9999 ← CI 0000	0000

4. The amount emitted from the counter is punched in columns 11 - 14.

5. Counter 5 stands at 0 at the beginning of the card cycle, because it was reset in the last program cycle. A 1 is added by means of a CI impulse in every working cycle.

	Contents of counter	Counter Exit
Card cycle	0000 ← CI 0001	
Program step 1	0001 ← CI 0002	0001
Program step 2	0002 ← CI 0003	0002
Program step 3	0003 ← Reset 0000	0003

6. The amount emitted from counter 5 is punched into columns 21 - 24.

7. Counter 6 reads in the digit 3 in complementary form from the master card in the same way as counter 1.

8. Co-selector 5, in contrast to co-selector 1, is transferred only during program cycles.

9. Counter 6 accepts a CI impulse only during program cycles. In the last program cycle, in which it is reset, the CI impulse has no effect.

10. Counter 6 reads out in every program cycle. Conversion Control (as for counter 1) is also impulsed at this time.

The cycle sequence shows how the method of operation differs from that of counter 1:

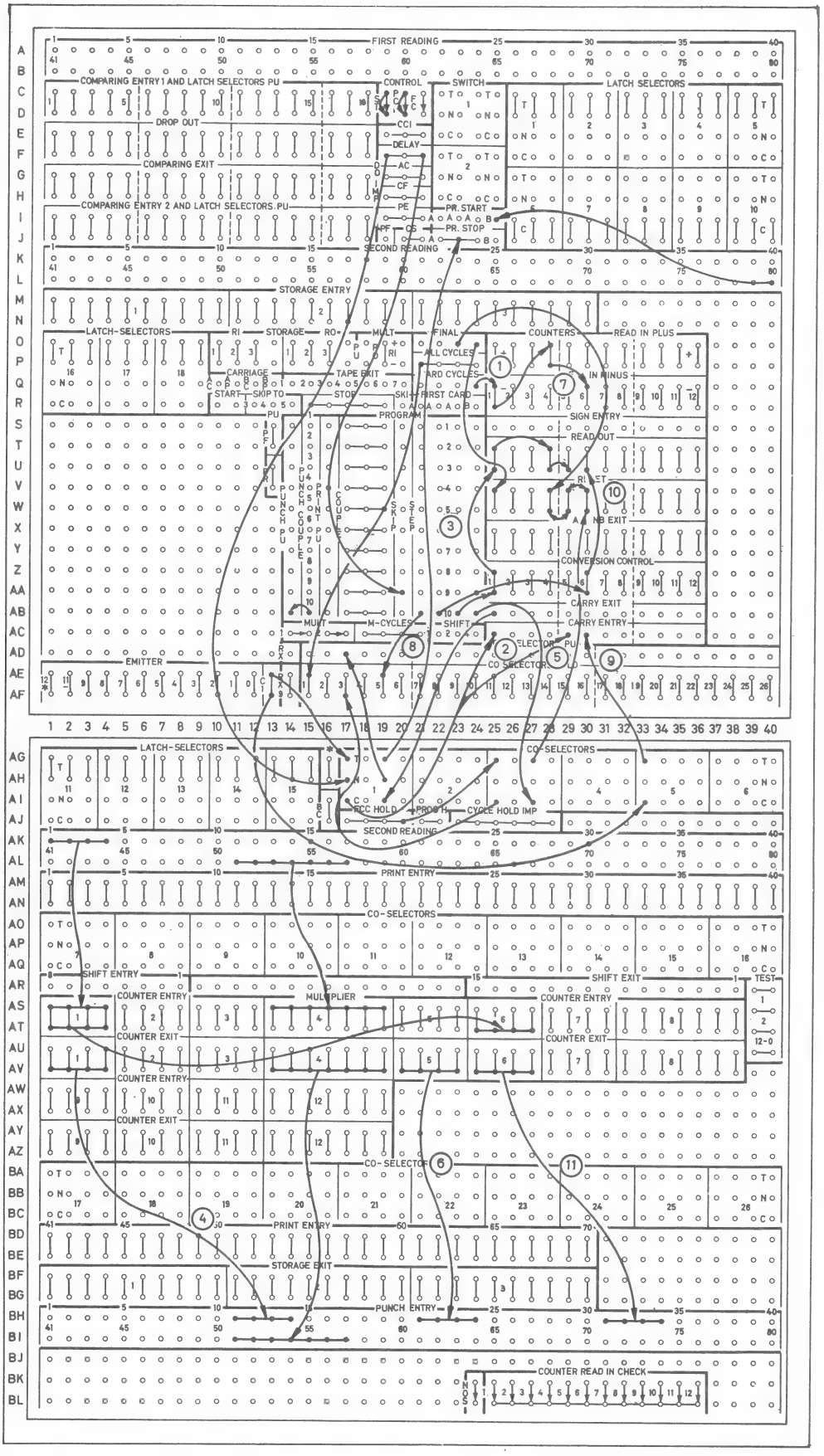
	Contents of counter	Counter Exit
Card cycle	9996 ← No CI 9996	
Program step 1	9996 ← CI 9997	0003
Program step 2	9997 ← CI 9998	0002
Program step 3	9998 ← Reset 0000	0001

11. The amount emitted from counter 6 is punched into columns 21 - 34.

When the Carry Entry of counter 5 is wired with connection 9, instead of connection 5, the following cycle sequence results:

	Contents of counter	Counter Exit
Card cycle	0000 ← No CI 0000	
Program step 1	0000 ← CI 0001	0000
Program step 2	0001 ← CI 0002	0001
Program step 3	0002 ← Reset 0000	0002

The counter would thus give numbers in ascending sequence, starting from 0.

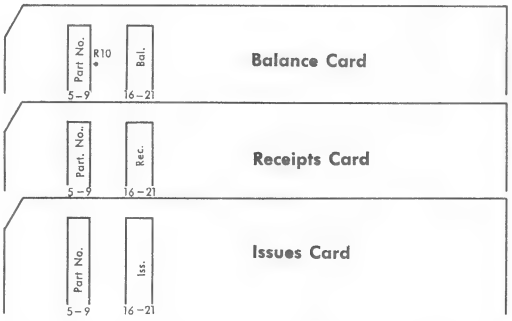


Wiring No. 23 Counter controlled gang punching with serial numbering

Wiring No. 24

Stock control (or balancing)

Three classes of cards are used in this application:
Balance cards,
Receipts cards, and
Issues cards,
which are sorted by part number, so that within a group (part number) the balance card is placed first and is followed, if applicable, by receipts cards and issues cards.



Line	Part No.	Old Balance	Movements: Received	Movements: Issued	New Balance
1	14711	300			
2			100		
3				50	
4					350
5	14713	23100			23100
6	14720	500			500
7	15213	10			
8			60		
9					70
10	15214	320			320
11	16320	8000			
12			500		
13				20	
14				130	
15				50	
16				30	
17				80	
18					8190
Print Positions:	2 – 6	10 – 15	19 – 23	28 – 31	35 – 40
Print Field	1	2	3	4	5

The illustration shows the card layout and the report which is to be printed from these cards.

The part number is only to be printed once for each group and will always be read from the balance card, which is the first card of a group to be sensed Balances, receipts and issues are punched in the same columns in all three card types, but are to be printed in different fields on the form. The card types are therefore identified by overpunching: balance cards have an R in column 10, issues cards have an X in column 80.

The balances and the receipts are added into a counter, the issues subtracted. For each part number, if movement has occured, the new balance is calculated and printed in the appropriate print field. At the same time, a new balance card is punched.

If, for a part number, only a balance card is present and there are no accompanying movements cards, this is treated as an unchanged balance card. In this case the counter is not added, no program takes place and the new balance (which has not altered) is simultaneously printed in both print fields.

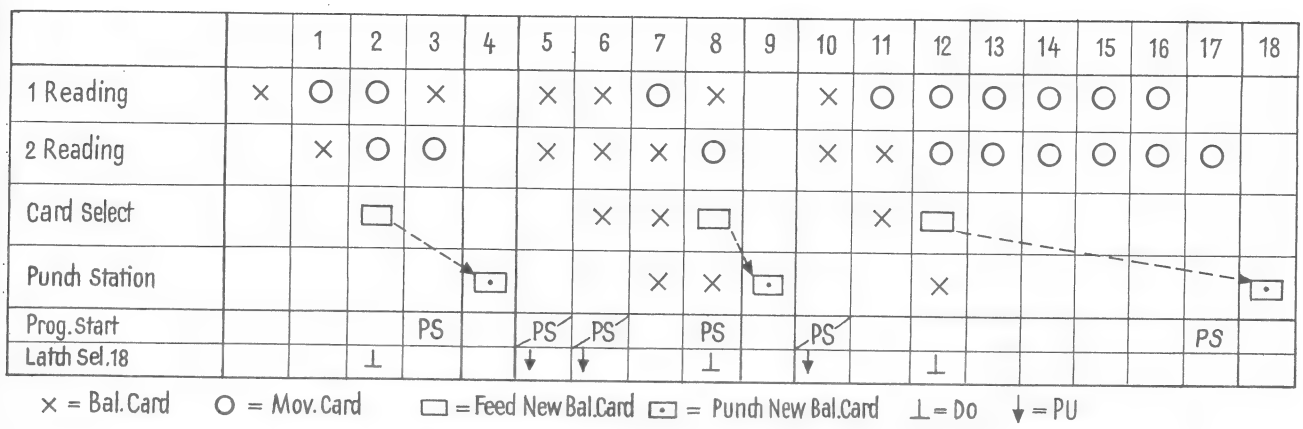
For this part number, no balance card need be punched. The unchanged balance card is selected into stacker 2. At the end of the run, up-to-date balance cards for all part numbers are in stacker 2, while stacker 1 contains movement cards as well as the old balance cards.

N.B. This example describes stock control. The principle remains the same in a book-keeping application; in this case the cards are called accounts balance cards and transaction cards, instead of stock balance cards and movements cards.

Whereas the calculation for stock control concerns:
OLD BALANCE + RECEIPTS - ISSUES = NEW BALANCE;

that for book-keeping is
OLD BALANCE $\pm$ TRANSACTIONS = NEW BALANCE.

Cycle sequence



The following sequence diagram shows the sequence of cards through the machine. The cycles are numbered corresponding to the lines of the form, so that the individual functions of the example can be followed.

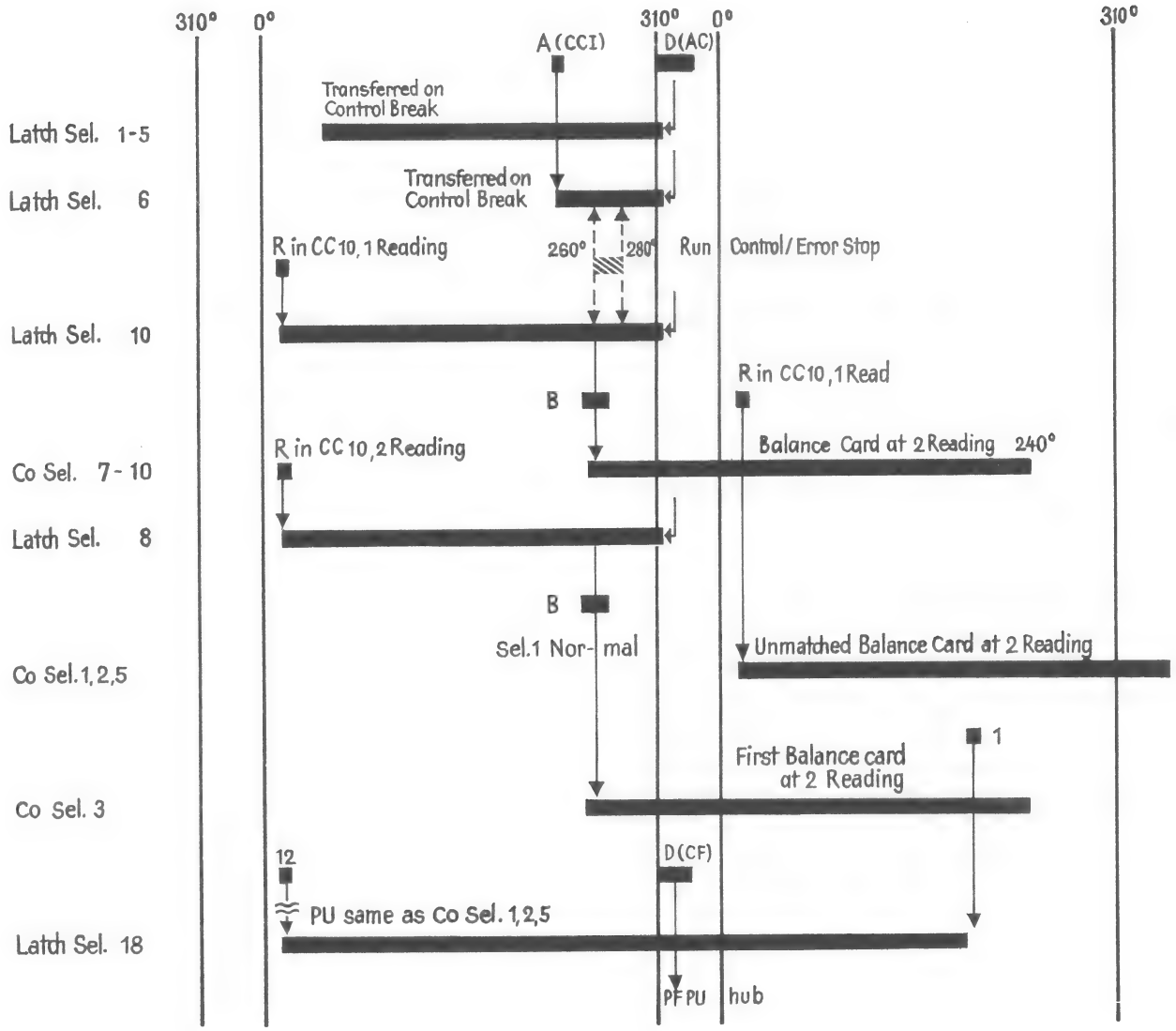
Unchanged balance cards can be recognized by the machine because they are followed by a further balance card. In other words, if a balance card is sensed at both reading stations (in this example in cycles 5, 6 and 10) then the card at the second reading station is an unchanged balance card and must be directed to stacker 2. Selection of this balance card is controlled by the 12 punch in the following balance card, by wiring this 12 punch to the CS hub through the Transferred side of a selector picked up when there is a balance card at Second Reading. In a similar manner, Counter read in is prevented for an unchanged balance card.

It should be noted that the last card cannot be selected if it is an unchanged balance card, since the 12 impulse from a following balance card is not present. A blank card with a 12 punch in column 10 should therefore be placed behind the last card of the deck, so that the previously mentioned balance card can be selected. This trailer card will be stacked in the first stacker.

Program Start A will be impulsed whenever there is a balance card at First Reading, since there can only be one balance card for each part number and therefore the card at Second Reading cannot belong to the same group. This is shown here in cycles 3, 5, 6, 8, 10 (and 17). The identifying punch of a balance card (R in column 10) could be wired directly to Program Start. Here, however, the normal method of group control using comparing selectors is to be preferred, because this will show up any sorting errors that may occur by the incorrect appearance of the printed report. In addition to this, the machine can be stopped if there is not a balance card at First Reading when a change in control number is sensed and vice versa.

Selector Control

The following timing diagram shows which impulses are used to pick up the individual selectors and for how long these selectors are transferred.



Explanation

Latch selectors 1 - 5 are used for comparing. Latch selector 6 is picked up by an A impulse wired through latch selectors 1 - 5 and is transferred on every change in control number. Latch selector 10 is transferred whenever there is a balance card at the first reading station. If the cards are correctly sorted, that is if there is one and only one balance card for each part number and these balance cards are the first in each group, the two latch selectors 6 and 10 are, at the end of a card cycle, either both normal or both transferred. It is possible, by these means, to stop the machine when, through a sorting error, these conditions are not satisfied. Co-selectors 7 and 10 are picked up by a B impulse from the Comparing Exit of latch selector 10 and are transferred when the balance card is at Second Reading. Latch selector 8 is picked up by an R punch in column 10 from Second Reading and is transferred (like co-selectors 7 - 10) when a balance card is at the second reading station. There is, however, the following difference between these possibilities: co-selectors 7 - 10 are transferred sufficiently early to be able to select a 12 impulse, while latch selector 8 is used, with the aid of a B impulse from the comparing exit, to produce a cycle delay. Co-selectors 1, 2 and 5 are transferred whenever there is an unchanged balance card at Second Reading. Co-selector 3 is transferred in the card cycle after a balance card was read at Second Reading, in case an unchanged balance card is concerned (= co-selector 1 normal); in other words: co-selector 3 is transferred when the first balance card is at Second Reading. Thus the co-selector may be used to feed a new balance card from the punch hopper for this group.

Latch selector 18 is picked up in the same way as co-selectors 1, 2 and 5, and thus transfers as soon as an unchanged balance card is sensed at Second Reading. The selector is used to direct an unchanged balance card through to the punch station. While this card is passing through the card select station, an impulse to the PF PU hub has no effect. In the next card cycle, the D impulse to these hubs causes the unchanged balance card to be transported to the punch station.

Latch selector 18 can remain transferred until a card is fed from the punch hopper and must then be dropped out by a "1" impulse through co-selector 3, because this card must remain before the punch station until after the last balance card has been processed. Any digit impulse could have been used instead of the "1" impulse.

Co-selectors 6, 12, 13 and 18 are not shown in the sequence diagram. Co-selector 6 is transferred in all card cycles and is used to control counter read in: counter 4 accepts in all card cycles in which there is no unchanged balance card (= co-selector 5 transferred) at Second Reading.

Co-selectors 12 and 13 are transferred when an issues card is at Second Reading and select the print field.

Co-selector 18 is transferred in program step 1 and causes an R to be punched in a new balance card.

Print field selection

Fields 1 and 2	are printed for all balance cards (co-selectors 7 and 10 transferred).
Field 3	is printed for receipts (co-selectors 9, 10 and 12, 13 normal).
Field 4	is printed for issues (co- selectors 9, 10 normal and 12, 13 transferred).
Field 5	is printed for new balances, either from an unchanged balance card during a card cycle (co-selectors 9, 10 and 1, 2 transferred) or from Counter Exit 4 during a program for a part number with a changed balance.

Below are explained the essentials of only those control panel connections which have not already been dealt with.

1. Latch selector 10 is picked up by an R punch in column 10 (= balance card at First Reading).

2. This 12 impulse is wired through the Normal side of co-selector 7 to pick up latch selector 18 and from there to the CS hub (= card selection of unchanged balance cards).

3. In addition to this, this impulse picks up co-selector 2 to which are coupled co-selectors 1 and 5 (transferred when an unchanged balance card is at Second Reading).

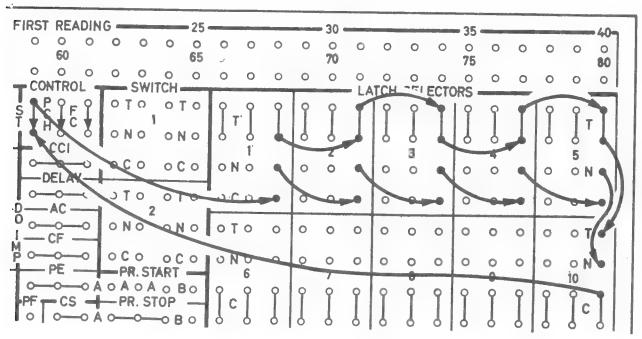
4. Program Start, instead of being wired from Comparing Exit, is picked up with an A impulse from the CCI hub so that the program can be suppressed for a single card group (= a group consisting of only one card).

5. A First Card A cycle impulse is provisionally wired to Program Stop so that a program will not occur for a single card group. If a number of single card groups follow one after the other, the First Card A hubs also emit, even though no program occured beforehand.

6. The latch selectors must be dropped out in every cycle, because otherwise, in the first cycle after a single card group, Program Start would be impulsed erroneously.

7. Run control is wired through latch selectors 6 and 10 in such a way that the connection is broken as soon as one of them is operated without the other. The machine therefore stops as soon as

a control break occurs without a balance card being at First Reading. Latch Selector 6 can be dispensed with if the connection from the upper to the lower hubs of the Control ST switch is wired directly through the contacts of latch selectors 1 - 5 as shown in figure 24a.



Wiring No. 24 a

8. Storage Read In is impulsed with a card cycle impulse wired through the Transferred side of co-selector 8 (= balance card at Second Reading). Only long cycle impulses may be used to control storage read in.

9. The storage reads in the part number from every balance card.

10. Storage Exit emits the part number for punching into the new balance card.

11. Counter 4 is read in for all cards, including unchanged balance cards.

12. Issues cards are subtracted.

13. In the program, the counter emits the new balance and is reset.

14. Counter Exit 4 is wired to Punch Entry. If the new balance is negative (which should not be allowed to happen in stock control), the Sign and NB Exit hub emits an 11 impulse which is wired to Conversion Control for counter 4 and may also be used for various other purposes.

15. In book-keeping applications, negative balances are possible. For these, a minus sign is printed and an 11 overpunched into the new balance card. If a negative balance is not permitted, this 11 impulse may be used to stop the machine or to print an identifying sign.

16. For each changed part number a new balance card must be punched. This card must be fed from the punch hopper at least one cycle before punching. This is achieved through a card cycle impulse wired through co-selector 3 (transferred when the first movement card is at Second Reading).

17. This card remains before the punch station (if further movement cards are present) until a program occurs. At the same time:

18. Latch selector 18 is dropped out, and

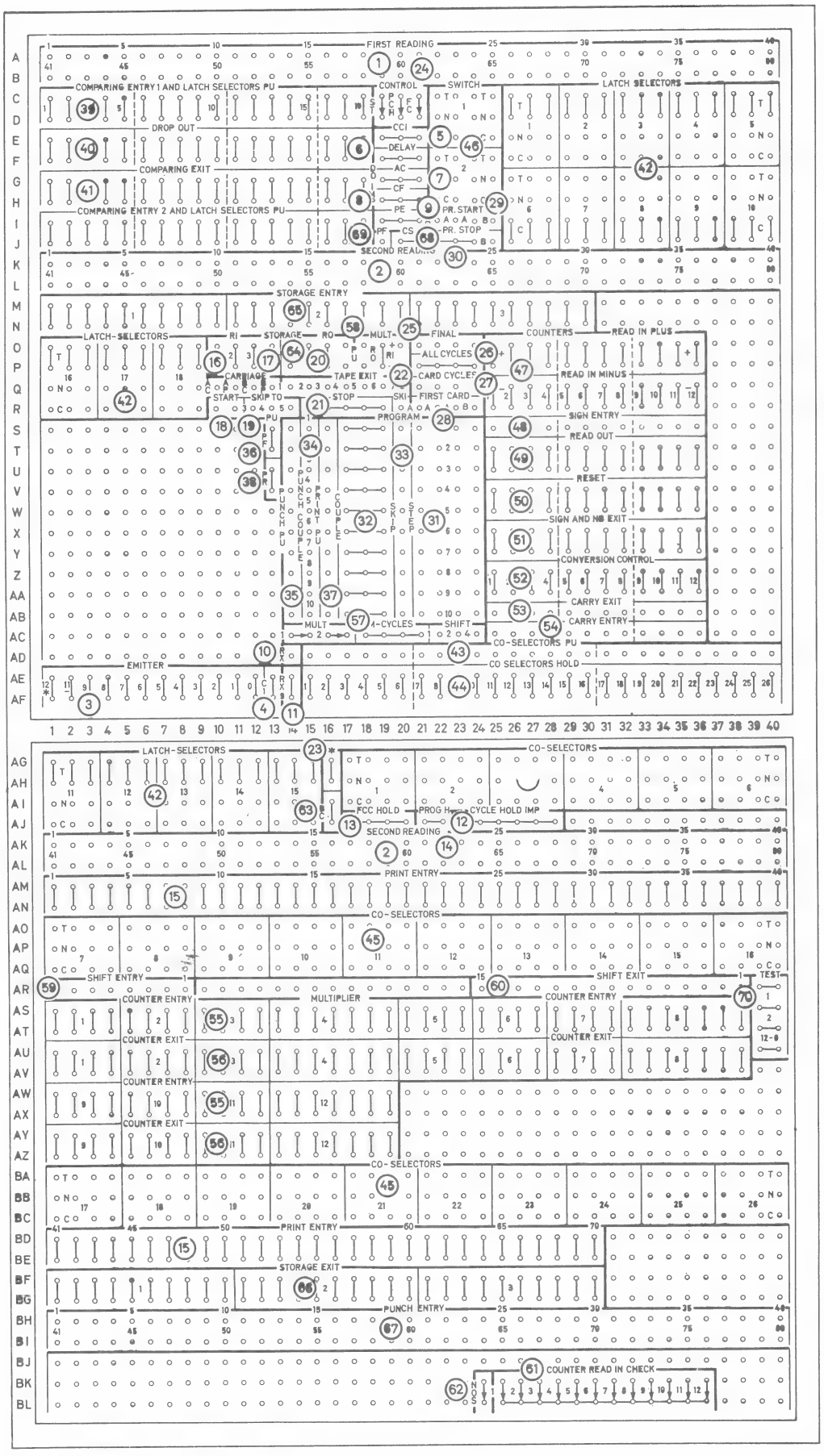
19. the unchanged balance card is transported through the punch station.

20. The carriage is wired for spacing (no control tape). Both the AC and the AP hubs are split-wired to one of the Carriage Start hubs, and cause single spacing after printing in card cycles and program cycles.

21. The Carriage BC impulse is wired to a second Carriage Start hub through the Transferred side of co-selector 8 and causes an additional single space before printing a balance card.

22. Carriage Stop is wired from any Tape Exit. Because no control tape is used, the choice of tape channel is of no importance.

For this wiring the Card Select and Punch keys (numbers 6 and 7) must be depressed.

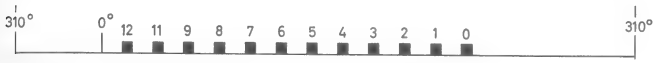


Control Panel Diagram

1. FIRST READING (A-B/1-40)

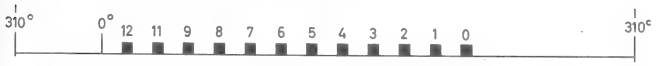
These 80 hubs emit impulses corresponding to the punches in the 80 card columns being read from the First Reading station. They are normally used in conjunction with the impulses from the Second Reading station for comparing. They can also be used to pick up selectors and for the control of other machine functions.

2. SECOND READING (K-L/1-40; AK-AL/1-40)



These 80 hubs emit impulses corresponding to the punches in the 80 card columns being read from the Second Reading station. To facilitate wiring, these hubs are duplicated on the control panel. The upper set of hubs is usually used for comparing, for the pick up of selectors and control of counters, while the lower set of hubs is wired to print positions and Counter, Storage, and Punch Entries.

3. EMITTER (AE-AF/1-12)



The Emitter emits digit impulses 12, 11, 9 .. 0. These impulses can be used, for example, through selectors if necessary, for entering constants into counters and for emitting constant data to be printed or punched. When certain machine functions are controlled directly with impulses from the Emitter, care must be taken in the wiring to ensure that stopping the machine at any time does not interfere with the correct operation of these functions. Impulses from the Emitter must never be split-wired together. For this reason, if alphabetic information is to be emitted, the digits for each letter must be combined through a co-selector picked up by an RX9 impulse.

4. CI (Carry Impulse) (AE-AF/13)

These double hubs emit an A-impulse in all machine cycles and are used similarly to the CCI hubs below.

5. CCI (Card Cycles Carry Impulse (E/19-21)

These triple hubs emit an A-impulse in all card feed cycles in which there is a card at the First Reading station. These impulses are used to pick up and drop-out selectors. They can also be wired, directly or through selectors, to Program Start, Program Stop (for example to suppress a program, picked up in that card cycle, under certain conditions), Multiplication Pick-up, Program Skip 1 - 9 (this is only effective if Program Start is simultaneously impulsed and is used to suppress certain program steps), SKI (Skip Interlock) or into the Carry Entry hub of a counter.

6. DELAY (F/19-21)

These hubs emit a B-impulse in all machine cycles, which is used primarily to delay machine functions for one cycle. This feature may be used in alphabetical field selection, when a co-selector must be picked up one card cycle later than the pick-up of another co-selector.

This impulse can also be used, through selectors, to pick up a program or a multiplication.

7. AC (Drop Out Impulse - All Cycles) (G/19-21)

These hubs emit a D-impulse in all machine cycles, except final cycles and idle cycles. These impulses can be used to pick up or drop out selectors, and can be wired through selectors if necessary, to Punch Pick Up 1-10, Punch Feed Pick Up (control panel reference S-T/13) and to the lower hub of the Control First Card switch (D/21).

8. CF (Drop Out Impulse - Card Feed Cycle) (H/19-21)

These hubs emit a D-impulse in every card feed cycle in which a card is sensed at the Second Reading station. This impulse can be

used to pick up or drop out selectors and can be wired, through selectors if necessary, to Punch Pick Up 1-10, Punch Feed Pick Up, and to the lower hub of the Control First Card switch (D/21).

9. PE (Drop Out Impulse - Program End) (I/19-21)

These hubs emit a D-impulse on every First Card cycle after a program. This impulse is normally used to drop out the comparing latch selectors. There is a difference between these hubs and the upper hub of the Control First Card switch (C/21): the Program End hub emits in the machine cycle after the last cycle of the program picked up by the last card of a deck, whereas the FC hub does not emit under these circumstances.

10. RX (Column Split Impulse) (AD/14)

This hub emits an E-impulse which lasts through 11-12 time of all machine cycles except idle cycles. This impulse can be wired to the Hold hub of a co-selector to cause the selector to work as a column split. With the aid of this column-split, digit impulses can be separated from control punches in the same card column, and a control impulse can be over-punched in the same card column as a digit. In addition, this impulse may be wired, through selectors if necessary, to the Print Pick Up hub (U-V/13) for selective listing.

11. RX9 (Zone Impulse) (AE-AF/14)

This hub emits an F-impulse which lasts through zone time (12, 11, 9) in all machine cycles except idle cycles. Co-selectors picked up with this impulse may be used to combine digits from the emitter to form alphabetic characters for printing or punching. If the zone impulses are wired through the Transferred side of such a selector, and digit impulses through the Normal side, the combined zone and digit impulses forming alphabetic characters are available from the Common hubs of the selector and may be wired to alphabetic print positions or to Punch Entries.

HOLD IMPULSES (AJ/17-28)

Three distinct Hold impulses are available for holding co-selectors in the transferred condition. These impulses may be wired through the Transferred side of a co-selector to that selector's Hold hub to cause the selector to remain transferred from the moment the pick up impulse is received until the end of the particular hold impulse used. In addition to these three special holding impulses, any other long impulse can be used for this purpose.

12. CYCLE HOLD IMP (All Cycles Hold Impulse) (AJ/23-28)

These hubs emit a Hold impulse, from 10° to 350° in all machine cycles, which may be used to hold a co-selector transferred in card cycles or program steps. This impulse must not be used directly to control other machine functions. It should be noted that an E-impulse cannot be selected through a selector held with this impulse.

13. FCC HOLD (Following Card Cycle Hold Impulse) (AJ/17-20)

These hubs emit a co-selector Hold impulse from 260° of a card cycle until 240° of the next card cycle. In idle cycles, program steps and during a multiplication, these hubs emit a long continuous impulse. Thus, it is possible to have a co-selector, picked up by a B-impulse and held with the FCC Hold impulse, transferred during the digit time of the following card cycle, even though a program intervenes between the two card cycles. It should be noted that the co-selector is transferred throughout this program.

14. PROG H (Program Hold Impulse) (AJ/21-22)

These double hubs emit a continuous co-selector Hold impulse during a program. This impulse begins, in a card cycle, at the time Program Start is picked up and ends in the last program cycle at 240°. Care should be taken to avoid back circuits to these hubs, otherwise an erroneous program may result.

15. PRINT ENTRY (AM-AN/1-40; BD-BE/1-30)

These 70 double hubs are entries, during print cycles, to the print unit. The first 5 and the last 40 print positions are numerical: print

positions 6 to 30 are alphanumerical. Each alphanumerical print segment can print the following characters:

26 alphabetical characters	A - Z
10 digits	0 - 9
3 symbols	* - .

Each numerical print segment can print the following characters:

10 digits	0 - 9
3 symbols	* - .

Asterisks and minus sign are printed by 12 and 11 impulses, respectively, from a card or from the emitter. The decimal point is printed in an alphanumerical print position by means of the 9-0 combination and in a numerical print position by means of a Carry impulse (A-impulse from the CI, CCI, Carry Exit and BC hubs). The decimal point cannot be printed directly from the card by a numerical print segment.

TAPE CONTROLLED CARRIAGE

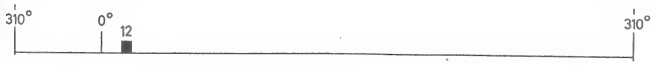
The following hubs are provided for the control of skipping:

Carriage AC, AP, BC, BP
Carriage Start
Skip to 3, 4, 5
Tape exits 1 - 7
Carriage Stop
SKI (Skip Interlock).

16. AC (After Hammer Trip, Card Cycles) (Q/10) AP (After Hammer Trip, Program Cycles) (Q/11)

The Carriage AC and AP hubs emit a C-impulse in all card and program cycles respectively in which the print unit is operative. If these "immediately after hammer trip" (252 - 257°) impulses are wired into one of the Carriage Start hubs, a carriage movement after printing is initiated. By this means, up to 22 spaces can be skipped between two print lines without loss of time.
When a skip after hammer trip is desired in both card cycles and program cycles, both of these hubs can be split wired to a single Carriage Start hub if the other hub is already in use, for example, if it is wired from a Carriage BC or BP hub. The AC and AP hubs can also be employed to control other machine functions, but they may not be split wired directly to other impulses.

17. BC (Before Hammer Trip, Card Cycles) (Q/12) BP (Before Hammer Trip, Program Cycles) (Q/13)

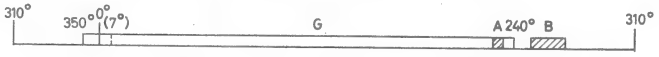


These two hubs emit a 12-impulse during all card cycles and program cycles, respectively, in which the print unit is operative. The impulse from these hubs may be wired into a Carriage Start hub in order to initiate a skip in the same cycle before printing takes place. A maximum of 14 lines may be skipped by such a "skip before printing".
The 12-impulse from these hubs can also be used to control other machine functions, and the BC and BP hubs may be split wired together in the same way as the hubs described above.

18. CARRIAGE START (R/10-11)

When either of these two independent entry hubs receives a short impulse (12-0, A or C), a carriage movement is initiated which continues until the Carriage Stop hub is impulsed. Normally only 12-impulses and C-impulses from the four hubs immediately above are used to control Carriage Start; however, other impulses can be used for this purpose - for example, digits read from a card. It should be noted that skips controlled by Skip To 3, 4 or 5 hubs overide carriage movement caused by an impulse to Carriage Start hubs, and that the Carriage Start hubs do not accept impulses when a Skip To hub has been impulsed. In other words, if, in a given cycle, a skip has been started by an impulse to one of the Skip To hubs, the Carriage Start hubs will not accept a C-impulse (AC and AP) in the same cycle nor a 12-impulse (BC and BP) in the following cycle.

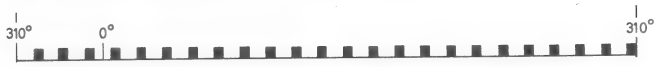
19. SKIP TO 3, 4, 5 (R/12-14)



If one of these three hubs receives an A, B or G cycle impulse, a skip is initiated which continues until a punch in the appropriate channel (3, 4, 5) of the paper tape is sensed. No further wiring (that is, from Tape Exit to Carriage Stop) is needed to achieve this.

If two of these hubs are impulsed simultaneously, the hub with the higher number takes priority.
The Skip To 3, 4, 5 may be used to control skips of up to 18 lines between two print lines without loss of time. For longer skips, the SKI (Skip Interlock) hubs must be wired, otherwise incorrect carriage operation will result: printing in flight will occur if the skip is of more than 22 lines; for skips of between 19 and 22 lines - controlled, for example, by an impulse to the Skip To 5 hub - a further skip to 5 will occur on the following card cycle, even though no skip was wired or skip to 4 was ordered.

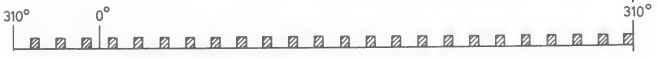
20. TAPE EXITS 1 - 7 (Q/14-20)



These seven hubs are the exit for the 7 channels of the paper tape. Each of these hubs emits a short impulse when the carriage is in motion and a punch is sensed in the appropriate channel. These impulses are normally wired into the Carriage Stop hubs in order to stop a skip started by an impulse to one of the Carriage Start hubs (this connection is not necessary for skips started by the Skip To hubs).
A punch in channel 7 is used to indicate the home position of the form. When the Carriage key and then the Final key are pressed, a carriage movement is initiated which is terminated by a punch in channel 7. In this way, the tape controlled carriage is restored to the first line of the form at the beginning of a run.

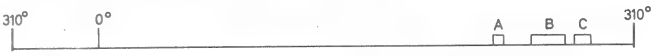
The remaining channels emit an impulse whenever a punch in the appropriate channel is sensed. Channel 5, however, is an exception to this: Tape Exit 5 does not emit an impulse during a skip initiated by an impulse to Skip To 3 or 4.
It is therefore possible to have an overflow program controlled by a punch in channel 5 on the last detail line if this line is reached while the carriage is spacing. If, however, this line is reached while a skip initiated by a Skip To 3 or 4 is taking place, the program will be suppressed. Other machine functions, such as Program Start, selector pick up and so on, can be controlled by an impulse from one of the tape exits. In this case, it should be noted that the timing of these impulses is not fixed, as are the other impulses, as they depend on the length of the skips. During skips, the platen is connected with the main drive of the machine and moves at a rate of 24 lines per cycle. The individual impulses occur between the lines. When the carriage is started at 275°, the first impulse (for a single space) occurs at about 290°. For a skip of 10 lines started at this time, the impulse occurs at about 80° in the next machine cycle. Knowledge of these timings is important if the tape impulses are to be taken through selectors.
Channel 6 is normally wired to SKI (Skip Interlock).

21. CARRIAGE STOP (R/15-19)



These hubs are only operative when the carriage is set in motion by an impulse to Carriage Start. They are normally wired, directly or through selectors, from the Tape Exit hubs immediately above them. These connections are made internally for skips initiated by an impulse to Skip To 3, 4, 5 hubs. In this case, it is not necessary to select other channels to Carriage Stop.

22. SKI (Skip Interlock) (R/20)



The carriage can perform skips, without loss of time, of up to 22 lines under the control of an AC or an AP impulse to the Carriage Start hub and of up to 18 lines if the skip was initiated by an impulse to a Skip To 3, 4, or 5 hub. For longer skips, carriage movement must be initiated by an impulse to one of the Skip To 3, 4, 5 hubs and, in addition, the SKI hub must be wired. The SKI hub is inoperative when the carriage movement is controlled by the Carriage Start hub. The SKI hub is normally wired from Tape Exit 6 so that it is impulsed when a punch is read in channel 6 of the tape. It is also possible, however, to wire an A, B or C-impulse to the SKI hub.
When the SKI hub is impulsed, the machine idles until the skip has been completed. For skips, not exceeding one or two lines (spacing), which are completed before 310°, no idle cycles are taken.

23. * (Program Cycle Symbol) (AG-AH/16)

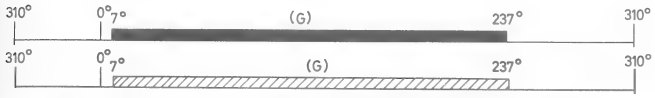
These double hubs emit a 12-impulse in all program print cycles and during final cycles. This is normally wired, directly or through selectors, to a print position to print an * (asterisk) to indicate a total.
N. B. BP is internally connected to the * hub, in such a way that an impulse received at the BP hub will be available at the * hub, though there is not a common connection in the opposite direction. Therefore for normal operation BP should not be commoned directly with any other hub.

24. CONTROL (Run Control Switches) (C-D/19-21)
ST (Start) (C-D/19)

The upper hub of this switch emits a continuous impulse as soon as and as long as the conditions for continuous running of the machine are satisfied. The upper and lower hubs of this switch must be connected, directly or through selectors, to allow the machine to run continuously. If this connection is not made, a depression of the Start key causes the machine to take one card or program cycle. This feature

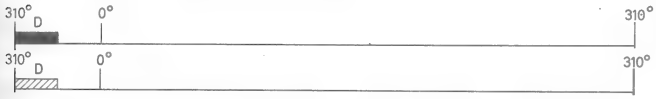
is invaluable in control panel testing for checking the program, cycle by cycle, since the program cannot be interrupted by merely pressing the Stop key. The lower hub emits an impulse from 280° to 260° in all machine cycles except for feed interlock, reset error and final total, when the hub is inoperative , and for multiplication, when it emits a continuous impulse. This hub must only be wired, directly or through selectors, to the hub immediately above it, otherwise damage to the machine may result.
When this switch is wired and the Start key is depressed, the lower hub emits an impulse, from 260° to 280° in every machine cycle, which permits continuous operation of the machine. If this connection is broken before 260° of a cycle, the machine stops at the end of the cycle. This connection must never be broken between 260° and 280°.

PCH (Punch) (C-D/20)



The upper hub of this switch emits a cycle impulse in all machine cycles in which there is a card at the punch station and punch feed is coupled. The PCH switch must be jackplugged for all applications in which punching is required. This connection can be selected if not all cards are to be punched.

FC (First Card) (C-D/21)



The upper hub of this switch emits a D-impulse in every First Card cycle after a program. If the switch is jackplugged, the First Card A hubs (R/21-23) emit a cycle impulse in every First Card cycle after a program. If the program was of level B, the B hub also emits. If the machine is group printing (tabulating), each First card cycle after program is also a print cycle.

The lower hub of this switch can also be impulsed with a D-impulse, for example AC or CF drop out impulses, selected if necessary. This causes the First Card A hubs to emit a cycle impulse in the same card cycle. If the Tabulate key is depressed, this cycle is also a print cycle. This is one of the ways of achieving "selective listing" without wiring the PR hub (U-V/13). If the lower hub of this switch receives a D-impulse during the program , the First Card A hubs emits a cycle impulse in the same program cycle, as also do the First Card B hubs if the program is of level B. However, this does not cause the First Card hubs to emit during the following first card cycle. To achieve this, the Control First Card switch must be jackplugged.

25. FINAL (O/21-24)

If the Final key is depressed and there are no cards in the card feed bed, these four independent hubs emit cycle impulses which may be used to print from counters or storage or to reset counters.
Note: When the Main Line switch is first turned on, the Start key must be depressed before the Final key becomes operative.

26. ALL CYCLES (P/21-24)

These hubs emit cycle impulses during all card cycles in which there is a card at the Second Reading station and during all program cycles. These impulses are slightly shorter than the normal card cycle and program steps impulses and are therefore more readily selected. They may be used, in the same way as normal card cycle and program cycles impulses, to control machine functions with the exception of storage read in and read out. These hubs do not emit during multiplication.

27. CARD CYCLES (Q/21-24)

These four independent hubs emit cycle impulses during all card cycles in which there is a card at the Second Reading station. These impulses may be used to control machine functions. The Card Cycle hubs do not emit during multiplication.

28. FIRST CARD A (R/21-23)
FIRST CARD B (R/24)

If the Control First Card switch is jackplugged, the three independent First Card A hubs emit a cycle impulse on every First Card cycle after a program. If the Tabulate key is depressed, the machine also performs a print cycle. If the preceding program was in level B, the First Card B hubs also emit.
Apart from this normal use, the first card A hubs emit a cycle impulse during each card cycle or program cycle in which the lower hub of the Control First Card switch receives a

D-impulse. The First Card B hub, however, can only emit during a program of level B or in the first card cycle following such a program.

PROGRAM CONTROL (I-J/22-25; S-AB/14-24)

29. PR START A (Program Start A) (I/22-24)
PR START B (Program Start B) (I/25)

30. PR STOP A (Program Stop A) (J/22-24)
PR STOP B (Program Stop B) (J/25)

When one of the three Program Start A hubs or the Program Start B hubs receives a short impulse (12-0, A, B or C) card feeding is interrupted and a program takes place. If, in a program of level A, the Program Stop A hub, or, in a program of level B, the Program Stop B hub is impulsed with a cycle impulse or an A-impulse, the machine terminates the program and a card is fed in the next machine cycle. Only one of the two groups of Program Stop hubs, Program Stop A or Program Stop B, is effective at any one time, dependent on the program level in force at that time.

If both Program Start A and Program Start B are impulsed simultaneously, Program Stop B is effective from the next machine cycle. Program Start B can also be impulsed in the course of an A level program, so that the program end is changed from the control of Program Stop A to that of Program Stop B. In this case, Program Stop B becomes effective from the beginning of the following program cycle.
If Program Start and Multiplication are impulsed simultaneously, multiplication will take place before the program. If Program Start and Program Stop are simultaneously impulsed in a card cycle, the program will be suppressed, provided the Program Start is not picked up by a B or a C-impulse.
If in a card cycle Program Stop A alone is impulsed and the Control First Card switch is jackplugged, the First Card A hubs emit a cycle impulse in the next card cycle. In addition, if the machine is group printing (tabulating), a print cycle occurs. This is one of the three methods of achieving "selective listing" by control panel wiring (See sections 24 and 38).

31. PROGRAM STEPS 1 - 10 (S-AB/21-24)

There are ten rows of Program Steps Exits, each having four independent exit hubs. These hubs emit full cycle impulses for the control of machine functions. The rows normally become operative consecutively in successive program cycles. If program step row 10 is reached before Program Stop is impulsed, the succession repeats and the first program step row (Program Step row 1) is the next to emit.

32. PROGRAM COUPLE 1 - 10 (S-AB/17-19)

Each program step row has associated with it a triple Program Couple hub. These hubs are used to couple the print unit during a program or to couple two program step rows so that they work together. Program step rows between two coupled rows are skipped; that is, their exits do not emit. This does not, however, apply if Program Step rows 1 and 10 are coupled together; in this case Program Step rows 2 - 9 are not skipped.

With the aid of Program Couple, it is also possible to pick up co-selectors so that they are transferred for that particular program step. These co-selectors may be used, for example, to create additional Program Steps Exits by selecting All Cycles impulses through their Common and Transferred points.

33. PROGRAM SKIP 1 - 10 (S-AB/20)

PROGRAM SKIP 1 - 9 (S-AA/20)

The Program Skip 1 - 10 hubs emit a B-impulse on every program cycle, with the exception of the cycle in which Program Stop is impulsed. Program Skip 1 - 9 are also entry hubs. A 0, A, B or C impulse wired to these hubs in a program, or in a card cycle in which Program Start is simultaneously impulsed, will cause the corresponding program step row and all preceding rows to be suppressed. In the next machine cycle the following program step row becomes operative.

34. PUNCH COUPLE 1 - 10 (S-AB/15)

These hubs emit a D-impulse in the program cycles in which the corresponding program steps row is operative. They are normally wired to Punch Pick up hubs to the left of them. When two program steps rows are coupled by means of their Program Couple hubs, only the upper Punch Couple hub emits.

Exception 1:
When Program Couple 1 and 10 are joined together, the Punch Couple 1 hub emits only on the first step; in steps 10, 19, 28 and so on (as long as Program Stop is not impulsed) only the Punch Couple 10 emits.

Exception 2:
When all ten couple hubs are joined together (one way of achieving a repetitive program cycle) the Punch Couple 1 hub only emits in the first program step and the Punch Couple 10 hub in all the following program steps.

Note: If a Program Couple hub receives an impulse in a card cycle, the Punch Couple hub in the same row immediately commences to emit an impulse which lasts until the end of that cycle (310^{O}). Care should be taken to avoid back circuits to the Punch Couple hubs during a program, as otherwise incorrect machine operation will result.

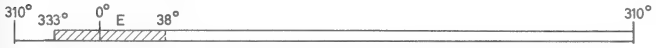
35. PUNCH PU 1 - 10 (S-AB/14)

These hubs are only operative in the corresponding program steps and must be wired from the Punch Couple hub to the right of them in order to punch a card at the Punch station.

36. PF PU (Punch Feed Pick up) (S-T/13)

These double hubs must be wired, through selectors if necessary, with a D-impulse from the CF hubs (H/19-21) if punching is required during card cycles.

37. PRINT PU 1 - 10 (S-AB/16)



These hubs are only effective in the corresponding program step and are normally wired from the Program Couple hubs to the right of them, if printing is required in a program cycle. Theoretically, the shorter E impulse from the RX hub is sufficient to pick up the print unit; this impulse is more easily selected, should printing not be required in every program cycle.

38. PR PU (Print Pick up - Selective List) (U-V/13)

These double hubs are only effective in card cycles if the Tabulate key is depressed. If the hub is wired, through selectors if necessary, with an E-impulse from the RX hub, the machine takes a print cycle.
Two other methods of achieving selective listing have already been given under sections 24 and 30.

COMPARING AND LATCH SELECTORS

The machine is equipped with 18 3-position Latch Selectors which may, if required, be used as a comparing unit.

39. COMPARING ENTRY 1 AND LATCH SELECTORS PU (C-D/1-18)
COMPARING ENTRY 2 AND LATCH SELECTORS PU (I-J/1-18)

Each Latch Selector has a pair of double hubs to pick up the selector and for comparing. The selector transfers immediately one of the pick up hubs receives an impulse and remains transferred until its Drop Out is impulsed. Long impulses, such as cycle impulses, must not be wired to these hubs. When both Pick up (entry) hubs receive an impulse at the same time, the selector remains normal. It is therefore possible to use a latch selector for comparing, by wiring the group control number from the First and Second Reading into the Comparing Entries 1 and 2 respectively.

40. DROP OUT (E-F/1-18)

Once a Latch Selector has been picked up it will remain transferred until its Drop Out hub receives an impulse. When the selectors are used for comparing, their drop out hubs are normally wired from the PE Drop Out hubs. Long impulses (Cycle impulses etc.) must not be wired to these hubs.

41. COMPARING EXIT (G-H/1-18)

Each Latch Selector has associated with it a double Comparing Exit hub which emits a B-impulse, in card feed cycles, when the selector is transferred. This impulse can be wired to start a program, for example, or to initiate a multiplication.

42. LATCH SELECTORS (C-J/26-40; O-R/1-9; AG-AJ/1-15)

Each of the three positions of a latch selector has, on the control panel, a Common hub (C), a Normal hub (N) and a Transferred hub (T). Normally, the C hub is internally connected

to the N hub; however, when the selector is transferred, the C hubs are internally connected to the T hubs.
These contact points can be used to select impulses controlling machine functions or to direct data flow within the machine. To facilitate wiring and to avoid the use of split wires, selectors 1 - 5 and 11 - 18 have double Transferred hubs, and selectors 6 - 10 have double Common hubs.

CO-SELECTORS

The machine is equipped with 26 4-position co-selectors which can be used, in a similar manner to the latch selectors already described, to control machine functions and the flow of data within the machine.
Each co-selector has two Pick up hubs.

43. CO-SELECTORS PU (AD/15-40)
44. CO-SELECTORS HOLD (AE-AF/15-40)

Both of these hubs are similar in function and can be wired with any impulse, long or short. The only difference between them is that the Hold hubs are double hubs, to facilitate control panel wiring when co-selectors are to be coupled together.

Co-selectors remain transferred only as long as one or other of their pick up hubs receives an impulse. When a co-selector is picked up by a short impulse, additional wiring may be needed to maintain the selector transferred long enough to carry out its functions. This can be achieved by wiring a longer impulse - for example, one of the special Hold impulses or a Cycle impulse - through the selector's Common and Transferred points into its own Hold hub. The selector will then be transferred from the beginning of the short pick up impulse until the end of this hold impulse.
When a co-selector has to be coupled with another co-selector, the Hold hub of the second selector must be connected to the Hold hub of the first selector, so that they both receive the same hold impulse.

45. CO-SELECTORS (AG-AI/17-40; AO-AQ/1-40; BA-BC/1-40)

Each co-selector has four positions. A selector position consists of three hubs on the control panel:
T (Transferred)
N (Normal)
C (Common)

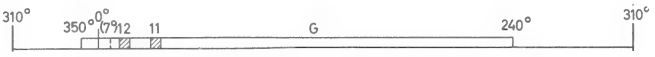
When the selector is normal, the C and N hubs are internally connected. When the co-selector Pick up or Hold hubs are impulsed, the C and T hubs are internally connected.

46. SWITCH (Alteration switches) (C-H/22-25)

On the top of the machine are two manually operated switches. Each switch controls a 4-position selector on the control panel. Normally, their Normal and Common hubs are internally connected together. However, if an Alteration switch is depressed, the Common and Transferred hubs of the particular alteration switch are internally connected. The alteration switches may be used to vary control panel wiring, so that a number of applications can be wired on the same control panel.

COUNTERS (O-AC/25-36)

47. READ IN PLUS
READ IN MINUS (O-R/25-36)



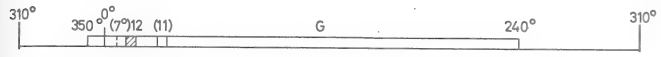
An 11 or 12 impulse from the card, a card cycle impulse, program steps exit or an 11-impulse from the Sign and NB Exit, can be wired to these hubs to cause the corresponding counter to read in information presented to the Entry hubs from the card, from another counter (total transfer), from a storage unit or, for constant information, from the emitter. This amount will be added or subtracted into the counter depending on which of the Read In hubs was impulsed. If both the Read In Plus and Read In Minus hubs receive an impulse in the same cycle - even though the impulses occur at different times, for example, an 11-impulse and a Cycle impulse - the counter will perform a subtraction.

48. SIGN ENTRY (S/25-36)

The Sign Entry hub of a counter is internally connected to the Sign and NB Exit hubs of that counter for all machine cycles in which the counter is not being read out. This feature enables sign impulses read from a card, as well as those being emitted from the counter when the counter is read out, to be wired to print from the counter's Sign and NB Exit hub. The minus sign, usually represented by an 11 punch in the junior position of a card field, may be wired from Second Reading through a column-split co-selector to the double hubs Read In Minus, so that the amount will be subtracted from the counter instead of being added into it, and from there taken to Sign Entry. In all cycles in which the counter is read-in minus, this X impulse is available from the Sign and NB Exit hubs and can be used to print a

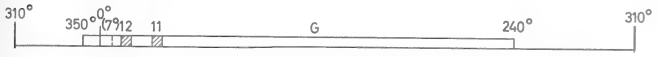
minus sign in a print position. This internal connection is broken when the counter is read out, and the Sign and NB Exit hubs emit an 11 impulse if the counter contains a negative balance.

49. READ OUT (T-U/25-36)



When these double hubs are impulsed with a 12, 11, card cycles or program steps exit impulse, the counter emits, from its Exit hubs, the amount standing in the counter. The counter can also be reset in the same cycle. An 11 impulse cannot be used to read out the counter if its contents may be negative and, at the same time, the Negative Balance impulse is to be wired to Conversion Control or to a print position.

50. RESET (V-W/25-36)

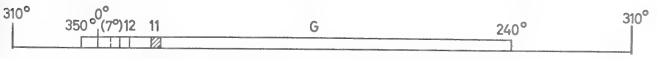


When these double hubs receive a 12, 11 or cycle impulse, the counter will be reset to zero. Reset can take place at the same time as counter read-out. If for any reason (for example, due to a control panel wiring fault) the reset does not take place correctly, the machine stops and the Test light comes on.

51. SIGN AND NB EXIT (X-Y/25-36)

The Sign and Negative Balance Impulse Exit of a counter is internally connected with the counter's Sign Entry hub for all machine cycles in which the counter is not read out. In machine cycles in which the counter is read out, this internal connection is broken and the Sign and Negative Balance Impulse Exit emits an 11 impulse if the counter contains a negative amount. Negative amounts in the machine are recognised by a 9 in the senior counter position and are held in a counter in complement form.
This Negative Balance impulse (11 impulse) is normally wired to Conversion Control and to print a minus sign in a print position or to punch an 11 punch, as negative identification, in a card column.

52. CONVERSION CONTROL (Z-AA/25-36)



Negative amounts are held in counters in complementary form. In order to print, punch or transfer this amount to another counter in true form, the Conversion Control hub of the counter must be impulsed. Normally, a negative balance (11) impulse is used for this purpose. However, a 12 impulse or a cycle impulse could be used.

53. CARRY EXIT (AB/25-36)

54. CARRY ENTRY (AC/25-36)

The Carry Exit hub emits a Carry impulse (A-impulse) in all machine cycles, except idle cycles, in which the highest order position of the counter has turned beyond 10; that is to say, cycles in which the counter wheel has turned from 9 through to 0.
The Carry Entry hub is an entry for A and B impulses in all machine cycles except idle cycles. An A impulse (Carry impulse) entering this hub will increase the amount in the counter by 1. By this means, two counters can be coupled together, to form one counter of a greater capacity, by wiring the Carry Exit hub of the low-order counter to the Carry Entry hub of the higher order counter.
When a counter is required to carry out subtractions, the Carry Exit hub must be wired to the Carry Entry hub of the same counter, so that the carry over from the highest position can be taken back into the junior position of the counter, to provide the correction necessary for operations in 9's complement form. Similarly, coupled counters which are to be used for subtraction must also have the Carry Exit hub of the high-order counter wired to the Carry Entry hub of the low-order counter. If only addition is to be performed, this wiring is not necessary. If a counter contains nines in all positions (= - 0), there is an internal connection, at Carry time (A and B impulse time), through all the counter positions, from the Carry Entry hub to the Carry Exit hub.

This fact makes possible two methods of controlling various machine functions, if the counter contains zero (strictly, minus zero):

1. An A impulse, from the CI or CCI hubs, wired into the Carry Entry hub, will be emitted from the Carry Exit hub if the counter contains 9 in all positions. At the same time, the counter will reset to zero in all positions.
2. If a B impulse was used under the same conditions, it would be emitted from the Carry Exit hub without affecting the amount contained in the counter. For this reason, this method is preferred for zero checking.

If an A impulse is wired into a Carry Entry hub and the counter's Read Out hub is impulsed at the same time, it is possible to increase the amount in the counter by 1 whilst the counter is reading out, without loss of time. This may be used to obtain serial numbers for printing or punching. In the same manner, the amount in the counter can be decreased by 1, without loss of time, and so yield serial numbers in descending sequence, if Conversion Control is impulsed at the same time, so making the counter operate on complements.

55. COUNTER ENTRY (AS-AT/1-38; AW-AX/1-19)

These hubs accept digit impulses, 0-9, from the Second (or First) Reading station, from counter exits, from storage exits or from the emitter, for addition or subtraction into the counter, if the corresponding Read In Plus or Minus hubs are impulsed. The Counter Entry hubs are only connected internally to the counter when counter read-in is controlled.

56. COUNTER EXIT (AU-AV/1-38; AY-AZ/1-19)

These hubs emit the amount held in the counter when the counter is controlled to read out. Counter exits can be wired to print positions, to the entry hub of another counter, to storage entries or to punch entries. The Counter Exit hubs are connected internally to the counter only when counter read out is controlled.

MULTIPLICATION

The machine is equipped with a multiplication device which is capable of multiplying an 8-digit multiplicand by a 7-digit multiplier to obtain a 15-digit product.
The machine can also use this device to perform division. A division, in contrast to multiplication, calls for a very complicated control panel wiring. It is not therefore possible to describe division in this brief control panel summary.
During multiplication, the machine takes multiplication cycles, which are three times as fast as the normal machine cycle. The positive multiplier must be held in counter 4; the positive or negative multiplicand can be held in any other counter; the product can be developed in any counters of sufficient capacity. For the majority of applications, it is convenient to choose counters 1 and 2 for the multiplicand and counters 6 to 8 for the product. The product is always developed as a positive number. If a negative multiplicand was used, the sign of the multiplicand must also be used for the product.

57. MULT 1, 2 (Multiply switches 1, 2) (AC/14-17)

These two switches must be jackplugged for every multiplication operation.

M CYCLES (Multiplication cycles) (AC/18-21)
SHIFT 1, 2, 4 (AC/22-24)

These hubs are only required for division and need not be wired for any other application.

58. MULT PU (Multiplication Pick Up) (O-P/18)

Two independent hubs are provided to control the start of multiplication. These will accept any of the short impulses 11 - 0, A, B or C impulses, to cause the machine to take multiplication cycles before the next card or program cycles.
During multiplication most other machine functions are suppressed (see Timing Chart).

MULT RO (Multiplication Read Out) (O-P/19)

These hubs emit a read out impulse, during all multiplication cycles, which should be used to read out the multiplicand counters.

MULT RI + & - (Multiplication Read-in Plus and Minus) (O-P/20)

These hubs are wired to Read-in Plus and Read-in Minus respectively of the product counter, to control the positive or negative read-in of the multiplicand to the product counter through the column shift unit.

59. SHIFT ENTRY (AR/1-8)

These hubs are wired from the Counter Exit of the multiplicand counters.

60. SHIFT EXIT (AR/24-38)

These hubs emit the shifted multiplicand throughout the multiplication. They are wired to the Counter Entry hubs of the product counter.

61. COUNTER READ-IN CHECK (BK-BL/25-36)

A Counter Read-in Check switch is provided for each counter. When this switch is jackplugged, the corresponding counter is checked, on every cycle in which it is controlled to read in, except during multiplication, to ascertain that each counter position has received an

impulse. If, due to a control panel wiring error or to unpunched columns in the card field being read in, any of the counter positions receive no impulse, the machine is stopped at the end of that cycle. At the same time the Test light comes on (Final key)and flashes. To resume operations, the start key must be depressed twice. The first depression of the key extinguishes the Test light. The second key depression restarts the machine. If the counter is to be read in from a card field smaller than the counter's capacity, the unused high order positions of the counter must be wired from the zero hub of the emitter. The same applies in total transfer operations if the receiving counter is of greater capacity than the counter being read out.

WARNING:
The upper hubs of these twelve switches are exit hubs in every cycle in which the corresponding counter is read out - because of this they must under no circumstances be wired to any hub other than the common hubs immediately below them, as otherwise the counter contacts will be damaged. However this connection may be selected, if for example Counter Read-in Check is not required in every cycle. The connection must not be broken by selectors, in this case, between 0 and A impulse times. When the counter read-in check device is not being used, the lower common hubs can be impulsed to stop the machine. For this purpose, a (selected) card or program step impulse should be wired to these hubs. The machine is then stopped at the end of this cycle and, at the same time, the Test light comes on and flashes.

62. NOS (No Stop) (BK-BL/24)

If it is not desirable to stop the machine when the counter read-in check device detects an error, the No Stop switch should be jackplugged. The Test light will then only come on once in the cycle in which the counter read-in check detected the error. This connection can, if required, be selected, but care should be taken to avoid breaking the connection during 0 and A impulse times.

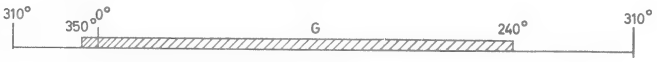
63. BC (Blank Column) (AI-AJ/16)

These double hubs emit an A impulse in every cycle in which the counter read-in check detects an error, if the No Stop switch is jackplugged. This impulse can be used to print a decimal point (.) in a numerical print position or to control certain machine functions with the aid of selectors. The decimal point will print on the same line as the card in which the blank column was detected. Since the read-in check can be selected at will for each counter, it is common practice to wire Counter Read-in Check for all counters which are to read in information from card fields in which zeros are punched.

STORAGE (O-P/10-12; O-P/14-16; M-N/1-30; BF-BG/1-30)

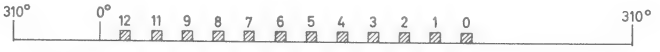
The machine is equipped with three 10-position storage units. Each storage position can accept, store, and read out as often as required, any digit alphabetic character, symbol or other combination of punches (multiple punching in a single column). A storage unit can read out all stored information and read in new information in the same cycle.

64. STORAGE RI (Read In) (O-P/10-12)
STORAGE RO (Read Out)(O-P/14-16)



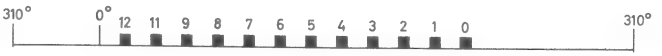
For each of the three storage units there is a double hub to control read-in and another double hub to control read-out. These may be wired from any (selected) Cycle impulse, with the exception of the All Cycles impulse. Each time a storage unit is read in, the previous contents of the storage are reset. If storage Read Out and Read In are impulsed simultaneously, the storage reads out the old information, resets and accepts new information in the same cycle.

65. STORAGE ENTRY (M-N/1-30)



These 30 double hubs are entries for the three storage units. They can be wired from the Second (and First) Reading stations, from counter exits and from the emitter, as well as from the Exit hubs of another storage unit or another part of themselves.
The A-impulse (Carry impulse) cannot be stored.

66. STORAGE EXIT (BF-BG/1-30)



When the Storage RO hub of a storage unit is impulsed, the 10 double Storage Exit hubs of the corresponding storage unit emit the stored information. Storage exits can be wired to print positions, to counter entries, to punch entries or to the Entry hubs of another storage unit.

67. PUNCH ENTRY (BH-BI/1-40)

These hubs are entries, during punch cycles, to the 80 punch positions. To permit a card to be punched, the following conditions must be satisfied:

1. Either or both of the Punch and Card Select Keys (No. 6 and 7) must be depressed.
2. There must be a card at the Punch station.
3. There must be cards at the Reading stations for punching during card cycles.
4. The Control PCH switch must be jackplugged.
5. One of the eleven Punch Pick-up hubs must receive a D-impulse.

68. CS (Card Select) (J/20-21)

Provided that key No. 6 Card Select is depressed, a 12 impulse from a card or from the emitter during a card cycle, wired into the CS hubs will cause the card passing Second Reading in this cycle to be directed through the Card Select station to the Punch station and so stack in Stacker 2, instead of preceeding to Stacker 1 as it would otherwise do. Card Select may be used to allow the results to be punched into the card from which the original factors were read, or to permit selective stacking. For example, to select heading cards from detail cards. If, for the purposes of illustration, the machine cycle in which a card passes a Second Reading station and the CS hub is impulsed is known as cycle 1, the card passes through the Card Select station in cycle 2 and may be punched in the third or a later machine cycle. In normal program operations, this card cannot be punched earlier than the second program cycle. However, if the program is preceded by a multiplication, then the card can be punched in the first program step.

69. PF (Punch Feed) (J/19)

If both the Card Select and the Punch keys (No. 6 and 7) are depressed, no cards will be fed automatically from the punch hopper into the Punch station, since it is possible for a card from the first hopper to pass into the punch unit through the card select station. Therefore, if, in a combined application, a summary card has to be fed from the punch hopper, the PF hub must be impulsed with a cycle impulse at least one cycle before this card is required at the Punch station.
The PF hub is inoperative if there is a card from the Second Reading station at the Card Select station in that particular cycle.

70. TEST 1, 2, 12-0 (AR-AU/39-40)

These hubs are only for the use of the Customer Engineer.

TIMING CHART

The Timing Chart is an invaluable aid to control panel wiring for this machine. It is designed to show which control panel wiring is permissable for all normal applications. A good knowledge of the machine functions is required. This timing chart should therefore only be used in conjunction with the Control Panel Summary.

The individual machine functions each take place at a given point in a machine cycle of 360°. For most purposes, machine cycles can be divided simply into card cycles and program cycles. However, for this timing chart, it is necessary to differentiate between many more types of cycle.

From a wiring point of view, the machine cycle begins at 310°. Thus, the timing chart shows a functional cycle from 310 to 310°. The hubs are arranged primarily according to impulse timings, with Exit hubs first, followed by Entry hubs. Those hubs which can be either exit or entry hubs are therefore shown twice. All the entry times shown may be used but the shaded portions are to be preferred. The Control Panel Summary should be referred to in case of doubt.

Some hubs are not shown in this timing chart, for example selectors, multiplication, counter read-in control and so on, since their methods of wiring are either self-explanatory or rigidly standardised so that a precise knowledge of their impulse time is not necessary.

Exit impulses can be divided into short and long impulses: short impulses 12-0 (Digit impulses) serve principally for data flow in the machine but may be used in the same way as the A to F impulses for control of the various machine functions. In this category come also the Tape Exit impulses (Tape Exits 1-7).

Long impulses include the G-impulse (cycle impulse), the hold impulses and the impulses for run control.

The following rules of wiring should be followed:

1. Entry hubs should only be wired with the impulses indicated.
2. Only short impulses should be used to pick up or drop out latch selectors.
3. Connections passed through selectors must not be broken while the impulse is passing, otherwise the selectors will be damaged.

The following abbreviations are used:

I	Idle cycles (as soon as the main line switch of the machine is turned on).
C1	All card feed cycles in which there is a card at the First Reading station.
C2	All card feed cycles in which there is a card at the Second Reading station.
FC	First card cycle after a program
LC	Last card cycle before a program
P	Program cycles, excluding the last cycle of the program.
LP	Last cycle of the program
M	Multiplication cycle
F	Final
x	Impulse under normal conditions
*	Impulse under certain other conditions (see notes below)
p	In print cycles only
m	These hubs emit during multiplication at a rate of three times as fast as normal
▬	Exits
▨	Principle entry times
▭	Possible entry times

REMARKS:

1. Emits only in counter read-in cycles, in which counter read-in control is operative and one or more positions of the counter receive no impulse.

2. Emits, in addition to First Card, in those cycles in which the lower hub of the Control First Card switch receives a D-impulse.

3. Only if a card is to be punched.

4. This hub emits in the last card cycle immediately Program Start receives an impulse. Care must be taken to avoid back circuits to this hub in card cycles, to avoid calling spurious programs.

5. These hubs correspond to the 7 channels of the paper tape. The impulses are emitted when the carriage is in motion and a punch is sensed in the appropriate channel.

6. Continuous impulse, as soon as and as long as the run conditions are satisfied.

7. The lower hub of this switch is both an entry and an exit hub. It must therefore only be wired, either directly or through selectors, to the upper hub of this switch. The connection must not be broken between 260 and 280°. During multiplication, this hub emits a continuous impulse.

8. Program Start B can be picked up in the course of a program to cause the Program Stop B hub to be operative.

9. In the last card cycle, only if Program Start is impulsed at the same time.

10. The hubs are normally wired from Tape Exits 1 - 7. They do not accept during skips initiated by an impulse to Skip To 3, 4, 5. They can, theoretically, be impulsed with any of the impulses shown in the chart.

11. An A-impulse causes a carry over, a B-impulse does not. Thus a B-impulse alone may be used if a check is required and the counter is to remain with 9 in all positions (zero check).

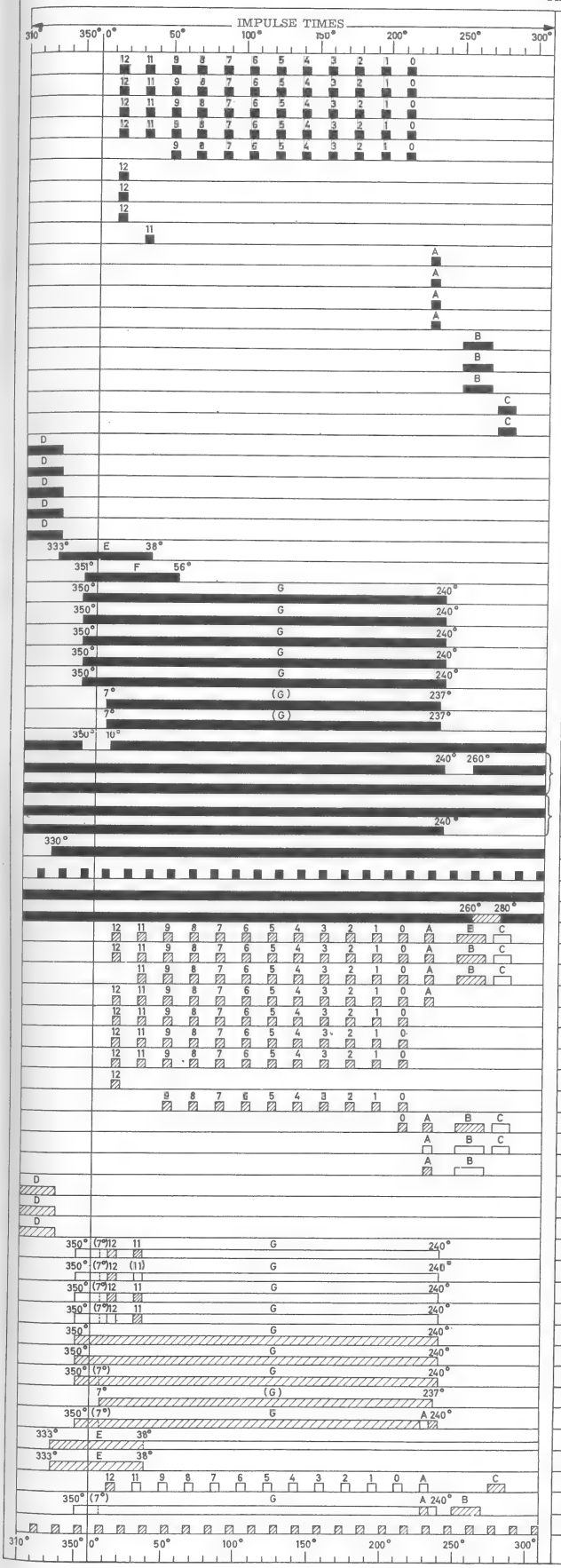
12. The hub is normally wired from the hub immediately above; it can also be picked up with any other D-impulse (see Note 2).

13. Counter Read-out must not be controlled with an 11 impulse if the counter contains a negative amount.

14. Storage Read-in and Read-out must not be controlled with a short Cycles impulse (All Cycles).

15. When Program Start A and Program Stop A are impulsed in the same card cycle, the program will be suppressed, if the Program Start was picked up an impulse between 12 and A times. The program will not be suppressed if Program Start is picked up with a B or C-impulse. If only Program Stop A is picked up in a card cycle and the Control First Card switch is jackplugged, then the First Card A hubs will emit a Cycle impulse in the next card cycle. If the machine is group printing (tabulating), a print cycle will also take place.

TIMING CHART



HUBS	LOCATIONS	CYCLES I	C 1	C 2	F C	L C	P	L P	M	F	REM.
Emitter	AE-AF, 1-12	x	x	x	x	x	x	x	x	x	
First Reading	A-B, 1-40		x								
Second Reading	K-L, 1-40;AK-AL, 1-40			x	x	x					
Storage Exit	BF-BG, 1-30		x	x	x	x	x	x		x	
Counter Exit	AU-AV, 1-38;AY-AZ, 1-19		x	x	x	x	x	x	m	x	
Carriage BC	Q, 12			p	p	p					
Carriage BP	Q, 13						p	p		x	
*(Program Cycle Symbol)	AG-AH, 16						p	p		x	
Sign and NB Exit	X-Y, 25-36		x	x	x	x	x	x	m	x	
CI (Emitter)	AE-AF, 13	x	x	x	x	x	x	x	x	x	
CCI (Drop Out Impulse)	E, 19-21		x	x	x	x					
Carry Exit	AB, 25-36		x	x	x	x	x	x	m	x	
BC (Blank Column)	AI-AJ, 16		*	*	*	*	*	*			1.
Delay (Drop Out Impulse)	F, 19-21	x	x	x	x	x	x	x	x	x	
Comparing Exit	G-H, 1-18		x	x	x	x					
Program Skip 1 - 10	S-AB, 20						x				
Carriage AC	Q, 10			p	p	p					
Carriage AP	Q, 11						p	p		x	
AC (Drop Out Impulse)	G, 19-21		x	x	x	x	x	x	x		
CF (Drop Out Impulse)	H, 19-21			x	x	x					
Control FC (First Card)	C, 21				x						
PE (Drop Out Impulse)	I, 19-21				x						
Punch Couple (1-10)	S-AB, 15						x	x			
RX	AD, 14	x	x	x	x	x	x	x	x	x	
RX9	AE-AF, 14	x	x	x	x	x	x	x	x	x	
Card Cycles	Q, 21-24			x	x	x					
First Card A	R, 21-23			*	x	*	*	*			2.
First Card B	R, 24				x						
Program Step 1 - 10	S-AB, 21-24						x	x			
Final	O, 21-24									x	
All Cycles	P, 21-24			x	x	x	x	x			
Control PCH (Punch)	C, 20			*	*	*	*	*			3.
Cycle Hold Imp.	AJ, 23-28	x	x	x	x	x	x	x	x	x	
FCC Hold	AJ, 17-20		x	x	x	x					
		x					x	x	x	x	
PROG H (Prog. Cycle Hold)	AJ, 21-22					*	x				4.
								x			
Program Couple 1 - 10	S-AB, 17-19						x	x			
Tape Exit 1 - 7	Q, 14-20	x	x	x	x	x	x	x	x	x	5.
Control ST (Start)	C, 19	*	*	*	*	*	x	x	x		6.
Control ST (Start)	D, 19	x	x	x	x	x	x	x	*		7.
Pr. Start A	I, 22-24					x					
Pr. Start B	I, 25					x	*	*			8.
Mult PU	O-P, 18		x	x	x	x	x	x			
Numerical Print Positions	AM-AN, 1-5, 31-40;BD-BE, 1-30			p	p	p	p	p		x	
Alpha. Print Positions	AM-AN, 6-30			p	p	p	p	p		x	
Storage Entry	M-N, 1-30		x	x	x	x	x	x		x	
Punch Entry	BH-BI, 1-40			x	x	x	x	x			
CS (Card Select)	J, 20-21			x	x	x					
Counter Entry	AS-AT, 1-38;AW-AX, 1-19		x	x	x	x	x	x	m	x	
Program Skip 1 - 9	S-AA, 20					*	x				9.
Stop	R, 20			*	*	*	*	*			10.
Carry Entry	AC, 25-36		x	x	x	x	x	x	m	x	11.
Punch PU 1 - 10	S-AB, 14						x	x			
PF PU (Punch Feed PU)	S-T, 13			x	x	x					
Control FC (First Card)	D, 21			*	x	*	*	*			12.
Counters Read In	O-R, 25-36		x	x	x	x	x	x	m	x	
Counters Read Out	T-U, 25-36		x	x	x	x	x	x	m	x	13.
Counters Reset	V-W, 25-36		x	x	x	x	x	x	m	x	
Conversion Control	Z-AA, 25-36		x	x	x	x	x	x	m	x	
Storage RI	O-P, 10-12		x	x	x	x	x	x		x	14.
Storage RO	O-P, 14-16		x	x	x	x	x	x		x	14.
PF (Punch Feed)	J, 19			x	x	x	x	x		x	
Control PCH (Punch)	D, 20			x	x	x	x	x		x	
Pr. Stop A, B (Prog. Stop)	J, 22-25					*		x			15.
Print PU 1 - 10	S-AB, 16						x	x			
PR PU (Print PU)	U-V, 13			x	x	x					
Carriage Start	R, 10-11			x	x	x	x	x		x	
Skip to 3, 4, 5	R, 12-14			x	x	x	x	x			
Carriage Stop	R, 15-19	x	x	x	x	x	x	x	x	x	

Index

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